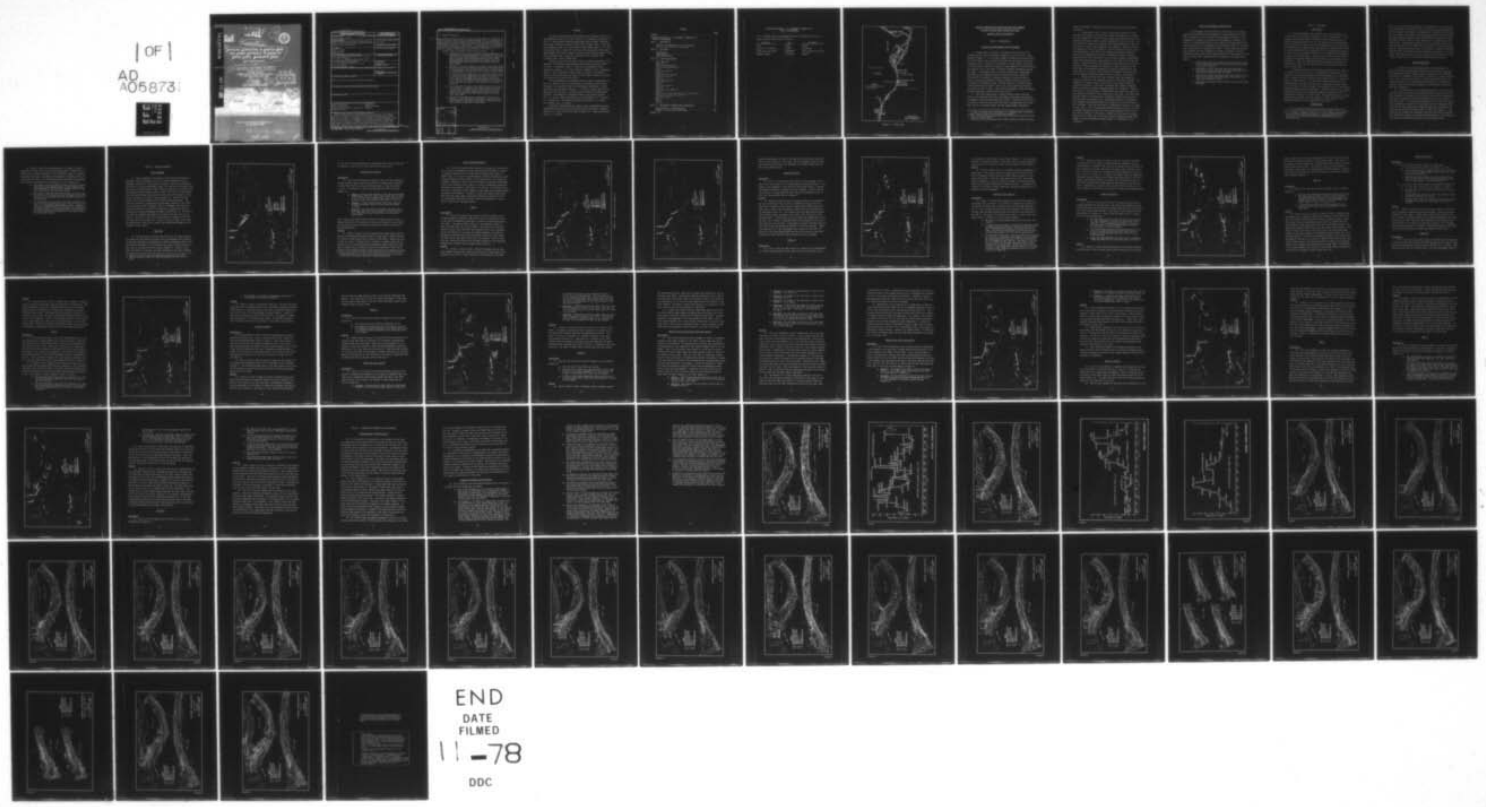
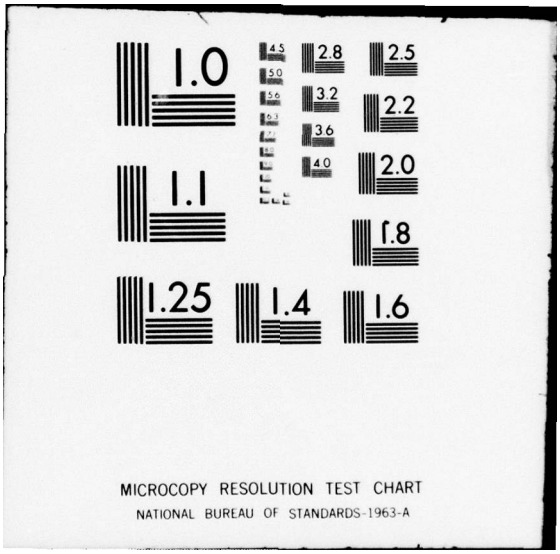
AD-A058 731 ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MISS F/G 13/2
SHOALING CONDITIONS IN SAWYER BEND AND LOWER ENTRANCE TO CHAIN --ETC(U)
JUN 78 J E FOSTER, C M NOBLE, J J FRANCO

UNCLASSIFIED WES-TR-H-78-7 NL

| OF |
AD
A058731



END
DATE
FILMED
11-78
DDC


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

LEVEL II

12

14 WES-TR-

TECHNICAL REPORT H-78-7

6 SHOALING CONDITIONS IN SAWYER BEND AND LOWER ENTRANCE TO CHAIN OF ROCKS CANAL, MISSISSIPPI RIVER.

Hydraulic Model Investigation.

by

10 James E./Foster, Charles M./Noble John J./Franco

Hydraulics Laboratory
U. S. Army Engineer Waterways Experiment Station
P. O. Box 631, Vicksburg, Miss. 39180

11 June 1978

9 Final Report.

13 72 P.

Prepared for U. S. Army Engineer District, St. Louis
St. Louis, Missouri 63101

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Technical Report H-78-7 ✓	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* SHOALING CONDITIONS IN SAWYER BEND AND LOWER ENTRANCE TO CHAIN OF ROCKS CANAL, MISSISSIPPI RIVER; Hydraulic Model Investigation		5. TYPE OF REPORT & PERIOD COVERED Final report 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) James E. Foster Charles M. Noble John J. Franco		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U. S. Army Engineer Waterways Experiment Station Hydraulics Laboratory P. O. Box 631, Vicksburg, Mississippi 39180		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U. S. Army Engineer District, St. Louis 210 N. 12th Street St. Louis, Missouri 63101		12. REPORT DATE June 1978 13. NUMBER OF PAGES 68
14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Chain of Rocks Canal	Sawyer Bend
Channel improvement	Sediment transport
Mississippi River channel improvement	Shoaling
Movable-bed models	

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This investigation was concerned with the development of an adequate channel and access to the docking facilities along the right bank in Sawyer Bend and the reduction or elimination of shoaling in the lower entrance to the Chain of Rocks Canal. The alignment of the channel upstream of Mosenthien Island and the movement of sediment from the Missouri River along the right bank caused an increase in flow through the chute channel to the left of Mosenthien Island and shoaling in the channel along the industrial docking facilities in Sawyer Bend. Shoaling in the lower entrance to the ~~(Continued)~~ Cont'

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

20. ABSTRACT (Continued).

CONT'

canal during low flows has created a serious problem because of the amount of dredging required and the lack of suitable disposal areas. The purpose of the model study was to develop plans that would provide a satisfactory channel in Sawyer Bend and reduce or eliminate the need for dredging in the lower entrance and approach to the Chain of Rocks Canal. A movable-bed model, constructed to scales of 1:250 horizontally and 1:100 vertically, reproduced the Mississippi River and adjacent overbank areas between miles 191.0 and 180.5.

Results of the investigation indicated the following:

a. Development of a satisfactory channel in Sawyer Bend can be accomplished by reducing the amount of flow through the chute channel to the left of Mosenthien Island and forcing the channel to cross toward the right bank farther upstream. This could be accomplished with the plan developed on the model and at the same time maintain some flow in the chute channel during all river stages.

b. Shoaling in the lower entrance to the Chain of Rocks Canal during low flows is caused by the sudden expansion of the channel width at the lower end of the trail dike which results in the movement of sediment-laden bottom currents into the canal approach channel.

c. A control gate at the upper end of the trail dike could be used to provide sufficient sediment-free flow into the entrance channel during low river stages which would tend to prevent the bottom currents and sediment from moving around the lower end of the trail dike and into the entrance channel. The effectiveness of the gate would depend on its size and type and method of operation.

d. A low wing dike at the end of the trail dike could be used to reduce the amount of shoaling in the lower entrance to the Chain of Rocks Canal. The effectiveness of such a structure would depend on flow conditions, elevation and length of the wing dike, and the amount of sediment moving along the river side of the trail dike.

e. Reduction of flow through the chute channel to the left of Mosenthien Island would tend to decrease the amount of sediment moving along the trail dike and the amount of shoaling in the lower entrance to the Chain of Rocks Canal.

PREFACE

The model investigation reported herein was conducted for the U. S. Army Engineer District, St. Louis (LMS), in the Hydraulics Laboratory of the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Mississippi, during the period of April 1972 to August 1975. The study was requested by LMS in a letter dated 17 March 1972, subject: St. Louis Harbor Model Study. Funds for the study were authorized in Intra-Army Order Number 76-72 dated 7 April 1972 and revisions thereto dated 21 July and 15 December 1972, 2 May and 20 September 1973, 8 August 1974, 13 August 1975, and 13 October 1977.

During the course of the model study, the LMS was informed of the progress of the study through monthly reports and preliminary results of tests. In addition, COL T. R. Peterson, LTC Richard W. Gell, Messrs. Art Johnson, N. C. Long, Claude N. Strauser, Steve L. Redington, Lester J. Boyer, William M. Genova, Gary W. Schwartz, and Robert P. Derrick visited WES during the course of the study to observe the model in operation and discuss test results.

The investigation was conducted under the general supervision of Mr. H. B. Simmons, Chief of the Hydraulics Laboratory, and Mr. Frank Herrmann, Jr., Assistant Chief of the Hydraulics Laboratory. Direct supervision was provided by Messrs. J. J. Franco, retired Chief of the Waterways Division, and J. E. Glover, present Chief of the Waterways Division. The engineer in immediate charge of the model study was Mr. J. E. Foster, assisted by Messrs. S. T. Mattingly, A. J. Cook, and H. S. Headley II. This report was prepared by Messrs J. E. Foster, C. M. Noble, and J. J. Franco.

Directors of WES during the course of this investigation and the preparation and publication of this report were BG Ernest D. Peixotto, CE, COL G. H. Hilt, CE, and COL John L. Cannon, CE. Technical Director was Mr. F. R. Brown.

CONTENTS

CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI)
UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
feet	0.3048	metres
miles (U. S. statute)	1.609344	kilometres
cubic feet per second	0.02831685	cubic metres per second
degrees (angle)	0.01745329	radians

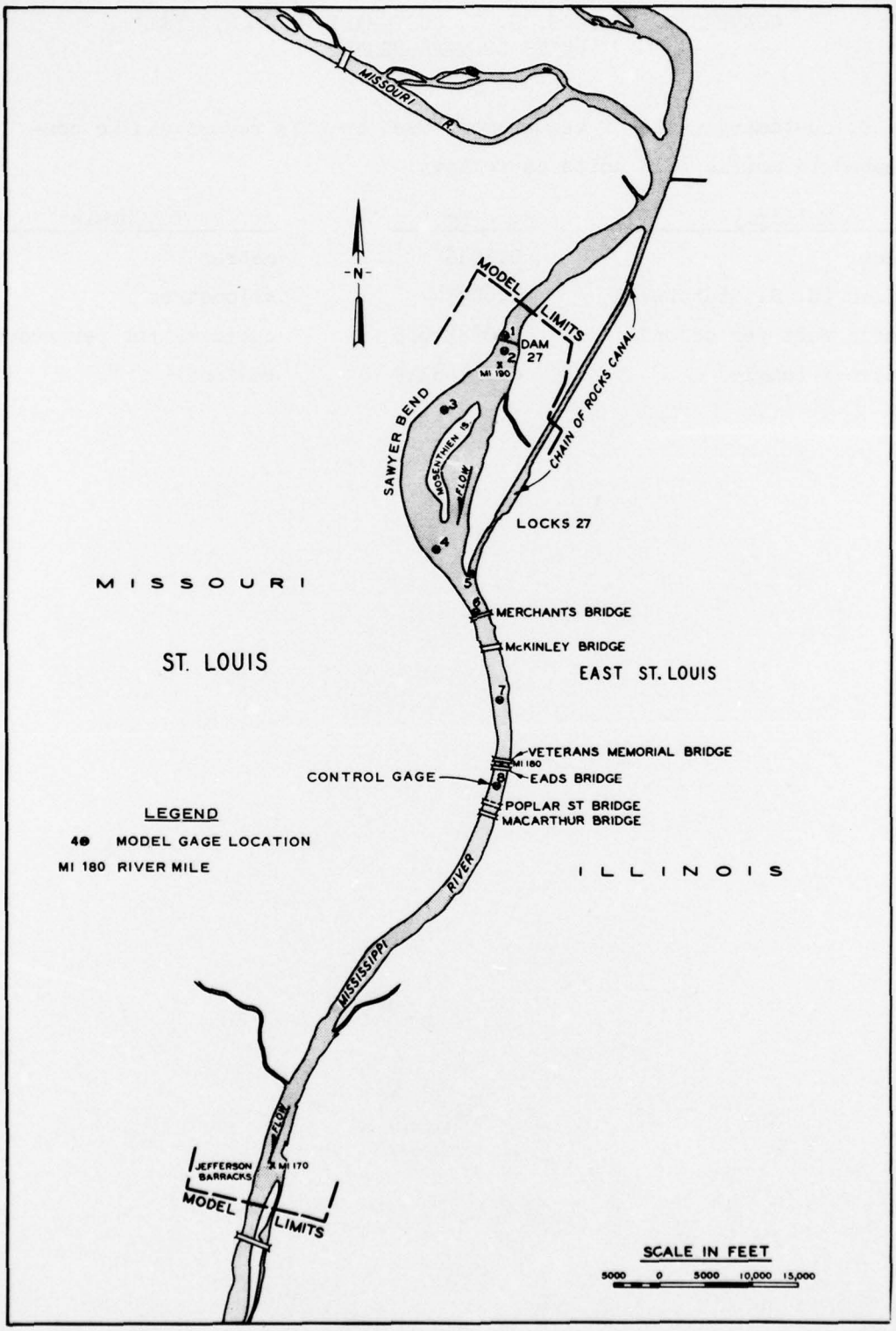


Figure 1. Vicinity map

SHOALING CONDITIONS IN SAWYER BEND AND LOWER ENTRANCE TO CHAIN OF ROCKS CANAL, MISSISSIPPI RIVER

Hydraulic Model Investigation

PART I: INTRODUCTION

Location and Description of the Prototype

1. Sawyer Bend is located in the Chain of Rocks reach of the Mississippi River near the northern boundary of the city of St. Louis, Missouri (Figure 1). In the reach, ledges of bedrock that extend across the river channel form a natural weir which has interfered with traffic during low flows. Because of the bedrock, a lateral bypass canal with a 1,200-ft* and a 600-ft lock (Locks 27) was completed in July 1953 along the Illinois side of the river to provide dependable navigation during all flows. In September 1963, a low-head, fixed-crest, nonnavigable dam (Dam 27) was completed across the Mississippi River channel at mile 190.3** to maintain a tailwater elevation at Locks and Dam 26 (Alton, Illinois) sufficient to ensure adequate depth over the lower lock gate sill during low flows. The dam consists of a broad-crested, 2,140-ft-long weir at crest el 395.0† and a low, 676-ft-long section (or notch) at crest el 391.0. The notch was designed to pass the design minimum discharge of 25,000 cfs at pool el 395.0.

2. The reach under study is located about 10 miles below the mouth of the Missouri River which contributes relatively large amounts of sediment, particularly during flood periods. During low-flow periods, velocities in the pool above Dam 27 are low, allowing some of the sediment load to be deposited above the dam; during higher discharges,

---

* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 3.

** Mile 190.3 and other locations so cited are in river miles above the mouth of the Ohio River.

† Elevations (el) cited herein are in feet referred to mean sea level.

larger percentages of sediment pass over the dam and into the channel downstream.

3. Downstream of Dam 27, flow is divided by Mosenthien Island with the chute channel to the left and Sawyer Bend channel to the right. The chute channel is in line with the channel upstream and has been continually developing to take a greater proportion of the total flow. Two rock dikes were constructed along the left bank upstream of the head of the island to reduce flow through the chute channel. However, the channel downstream of Dam 27 continued to follow along the left side, causing some erosion of the head of the island and deposition along the right bank in Sawyer Bend in front of industrial docking facilities. During the 1973 flood, portions of the two dikes upstream of Mosenthien Island were destroyed and a large portion of the head of the island was eroded. During the flood, flow through the chute channel to the left of Mosenthien Island increased from about 30 to about 70 percent of the total flow and considerable deposition occurred in Sawyer Bend to the right side of the island. The scouring of Mosenthien Island and movement of sediment downstream posed a threat to the St. Louis Harbor.

4. Between the time the Chain of Rocks Canal was dredged and placed in operation, heavy shoaling occurred in the lower entrance. The movement of a sandbar along the left side of the channel eventually blocked the entrance to the canal, indicating that frequent dredging would be required to maintain adequate depths for navigation. Based on the results of a model study, a 2400-ft-long trail dike was constructed that formed an extension of the right bank of the canal. The trail dike has been effective in reducing or eliminating shoaling during periods when the dike is overtopped, but a considerable amount of dredging has been required during periods when river stages are low and the dike is not overtopped. When the trail dike is overtopped for periods of 30 days or more, most or all of the material deposited below the end of the dike is eroded, leaving only some fine silt and mud between the end of the dike and the entrance to the canal. During low-flow periods, shoaling develops at the lower end of the trail dike and sometimes extends downstream to below the Merchants Bridge (Figure 1), depending on flow conditions.

Need for and Purpose of Model Study

5. Developments within the Chain of Rocks reach of the Mississippi River are affected by the movement of large quantities of sediment, divided flow, and the effects of structures and bedrock on the alignment and velocity of currents and the movement of sediment. Because of the complicated nature of the reach and the many interrelated factors involved in its development, an analytical solution to the problems involved would be extremely difficult. A model study was considered essential for the development of plans to eliminate or reduce shoaling along the right bank in Sawyer Bend and in the entrance to the Chain of Rocks Canal. Specifically, the purposes of the model study were to:

a. Develop plans that would reduce flow in the chute to the left of Mosenthien Island without excessively increasing flood stages upstream.

b. Eliminate or reduce shoaling along the right bank in Sawyer Bend without adversely affecting navigation using the docking facilities along the bank.

c. Eliminate or reduce shoaling in the lower entrance to the Chain of Rocks Canal and downstream of the end of the trail dike during low flows.

d. Determine the relative effectiveness of the various plans developed.

PART II: THE MODEL

Description

6. This investigation was conducted on an existing model previously used for the study of shoaling in the St. Louis Harbor. A description of the model and the results of that investigation are included in Technical Report H-72-7.* The model was of the movable-bed type, constructed to scales of 1:250 horizontally and 1:100 vertically. The fixed-bank and overbank areas were molded in sand-cement mortar and the movable-bed material was crushed coal with a median grain diameter of about 4 mm and a specific gravity of 1.30. Bedrock was simulated in the model with crushed stone. Folded strips of wire mesh were used to simulate the overbank roughness and resistance to flow caused by overbank growth. Since the investigation was concerned with problems upstream of mile 180, only the upper portion of the existing model was used for this study.

7. Fixed-bed portions of the model were molded from the edge of the movable bed to the top bank in accordance with data shown in the composite of surveys made during the period November 1959 to September 1966. Overbank areas were molded to data shown in the U. S. Geological Surveys of 1954 and 1955. The elevation of bedrock was based on an interpretation of general data shown in a small-scale bedrock surface map of the East St. Louis, Illinois, area prepared by the Illinois State Geological Survey (date not available). Location and height of training structures were based on construction drawings furnished by the U. S. Army Engineer District, St. Louis (LMS). The movable-bed portion of the model was in accordance with the prototype surveys of March 1971 and September 1966 prior to the adjustment tests (Plate 1).

Appurtenances

8. A circulating flow system was used to supply water to the

---

* J. J. Franco, "Shoaling Conditions, St. Louis Harbor, Mississippi River; Hydraulic Model Investigation," Technical Report H-72-7, Nov 1972, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

model. The inflow rate was measured at the upper end of the model with two venturi meters of different sizes to produce accurate measurements over the range of discharges to be reproduced. Water-surface elevations along the channel were measured with point gages spaced along the model. The water-surface elevation at Eads Bridge gage was controlled with an adjustable tailgate located at the lower end of the original St. Louis Harbor model. A graduated container was used to measure bed material that was introduced at the upper end of the model. A carefully graded rail was installed along each side of the channel to support sheet-metal templates used for molding the model bed prior to initiation of certain tests. These rails were also used to provide vertical control for surveying the model bed and for installing structures in the model.

Model Verification

9. Before tests of improvement plans can be undertaken in a movable-bed model, adjustments are made until the model can reproduce with reasonable accuracy changes that have occurred in the prototype. The process of adjustment of the model is referred to as model verification. The successful verification is used to establish the time and discharge scales, rate of introducing bed material for each flow reproduced, the model operating technique, and the degree of similitude that can be expected.

10. The verification of the Sawyer Bend-Chain of Rocks reach of the model was started with the movable-bed portion molded to the conditions indicated by the March 1971 prototype survey as far downstream as mile 184.0, including all of the structures in place in the river at that time (Plate 1). The model bed downstream of mile 184.0 was molded to the conditions indicated by the prototype survey of September 1966. The model was then operated by reproducing flows that occurred in the river during the period 13 March 1970 to 7 March 1971 (Plate 2). The operation was repeated and adjustments made until the model reproduced with reasonable accuracy the essential characteristics of the reach and the channel configurations indicated by the prototype survey.

11. Results of the final adjustment test are shown in Plate 3. A comparison of these results with the prototype survey of March 1971 indicates that the model reproduced with a reasonable degree of accuracy the general tendencies and channel configurations indicated by the prototype survey. Some of the differences between the model and prototype that should be considered in the evaluation of test results are:

a. The channel along the right side near the head of Mosenthien Island was somewhat deeper and the channel along the right bank at mile 187.0 was somewhat shallower than that indicated by the prototype survey.

b. The channel along the right bank between miles 185.8 and 184.6 was 2 to 6 ft deeper and the crossing at mile 184.0 was about 6 ft shallower than that indicated by the prototype survey.

c. The shoaling in the entrance to the Chain of Rocks Canal was not as much as that indicated in the prototype at the time of the September 1966 prototype survey. Actually a comparison between model and prototype in the entrance to the canal could not be made since flows in river prior to the 1966 survey were not reproduced in the model during the verification tests.

PART III: TESTS AND RESULTS

Test Procedure

12. After adjustment of the model, a base test was conducted to determine channel development with one or more reproductions of the hydrograph selected for testing and to provide a basis for determining the effects of various improvement plans. The base test was started with the bed of the model molded to the conditions indicated by the March 1971 and September 1966 prototype surveys. Most of the tests of improvement plans and modifications were started with the bed of the model the same as that obtained at the end of the preceding test. Other tests were started with the bed molded to 1971 and 1973 prototype surveys. The model was operated by reproducing the hydrograph recorded in the prototype during the period 1 Septemter 1966 to 2 September 1967 (Plate 4), except for special tests that were conducted by reproducing what was considered an average hydrograph furnished by LMS (Plate 5). The bed of the model was surveyed and mapped at the end of each run, and the entrance to the Chain of Rocks Canal was dredged to a depth of 12 ft* before the start of the next test. Results of tests of some of the plans and modifications that did not indicate any significant changes are not included in this report.

Base Test

13. The base test was started with the bed of the model molded to the conditions indicated by the March 1971 and September 1966 prototype surveys and conducted by reproducing the 1966-67 hydrograph (Plate 4).** The structures included in the model were the same as those existing in the river at the time of the 1971 survey (Figure 2). Results of the base test (Plate 6) indicate only small differences from those obtained

---

* Depths are in feet below the low water reference plane (lwrp).
** Unless otherwise noted, the 1966-67 hydrograph was used for all tests.

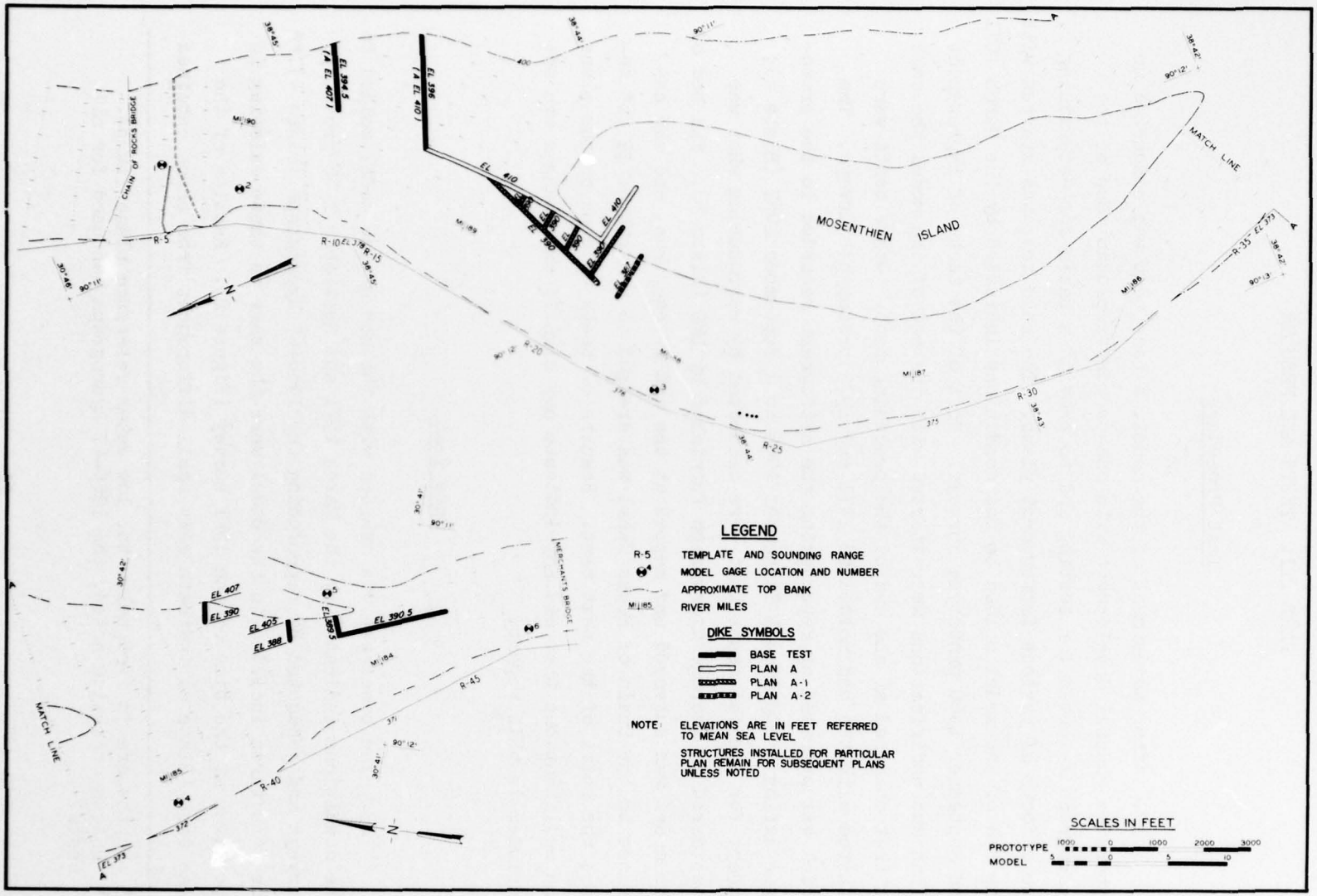


Figure 2. Base plan and plans A, A-1, and A-2

at the end of the verification test except that there was less shoaling in entrance to the Chain of Rocks Canal with the base test.

Plans A, A-1, and A-2

Description

14. Plan A and modifications (plans A-1 and A-2) were designed to provide adequate depths along the right bank in Sawyer Bend downstream of about mile 187.8 by closing Mosenthien chute to flows lower than el 410.0. The features of plan A and modifications were as follows (Figure 2):

a. Plan A. The two dikes upstream of the head of Mosenthien Island (miles 189.6 and 189.2) were raised from el 396.0 to el 407.0 and 410.0, respectively, and a dike was constructed across the entrance to the chute to el 410.0.

b. Plan A-1. A wing dike and baffle dikes were added at el 390.0, extending from the closure dike and angled riverward.

c. Plan A-2. The wing dike was extended downstream 200 ft and a spur dike with crest elevation of 387.0 was added along Mosenthien Island downstream of the wing dike (mile 188.3).

Test of plan A was started with the bed of the model molded to that obtained at the end of the base test, and tests of plans A-1 and A-2 were started with the bed of the model as existed at the end of the test of the preceding plan.*

Results

15. Tests of plans A and A-1 indicated that these plans would not provide a satisfactory crossing toward the right bank in Sawyer Bend and the results of these tests are not shown in the plates. Results of test of plan A-2 (Plate 7) indicate that a channel of adequate depth had developed over the crossing from along Mosenthien Island toward the right bank in Sawyer Bend and along the right bank downstream of mile 187.3; however, the crossing was about a mile downstream of the desired location.

* Unless otherwise noted, tests were started with the bed of the model as existed at the end of the test of the preceding plan.

Plan B and Modifications

16. Plan B and modifications (plans B-1 through B-6) involved the use of various combinations of vane and spur dikes designed to provide an adequate channel along the right bank in Sawyer Bend (Figure 3). Neither plan B nor any of the modifications provided satisfactory conditions; therefore only the results of the final test in this series are included. Results of tests of plan B-6 (Plate 8) indicate considerable scour in the entrance to the chute to the left of Mosenthien Island and shoaling in the channel to the right of the island. The crossing from the head of Mosenthien Island toward the right bank had developed farther upstream but was shallow. A channel of less than project depth developed along the right bank in the bend downstream to about mile 186.2. The developments indicated in Plate 8 were an accumulation of the effects of plan B and its modifications.

Plan C

Description

17. Plan C was based on the results of tests of plans A and B and was designed to provide a reduction in the flow through the chute to the left of Mosenthien Island and to develop a crossing upstream of mile 187.8. This plan, shown in Figure 4, was generally similar to plan B-6 except that the two vane dikes in the entrance to the chute channel at miles 189.0 and 188.9 were replaced with a dike extending across the entrance to the chute and angled riverward to provide an opening and some flow into the chute channel during all river stages. The dike on the right bank at mile 187.7 was removed. Tests of this plan were started with the bed of the model remolded to the conditions indicated by the March 1971 prototype survey (Plate 1).

Results

18. Results of test of plan C (Plate 9) indicate that an adequate channel had developed along the right bank in Sawyer Bend as far upstream as mile 187.8. Scour occurred in the entrance to the chute

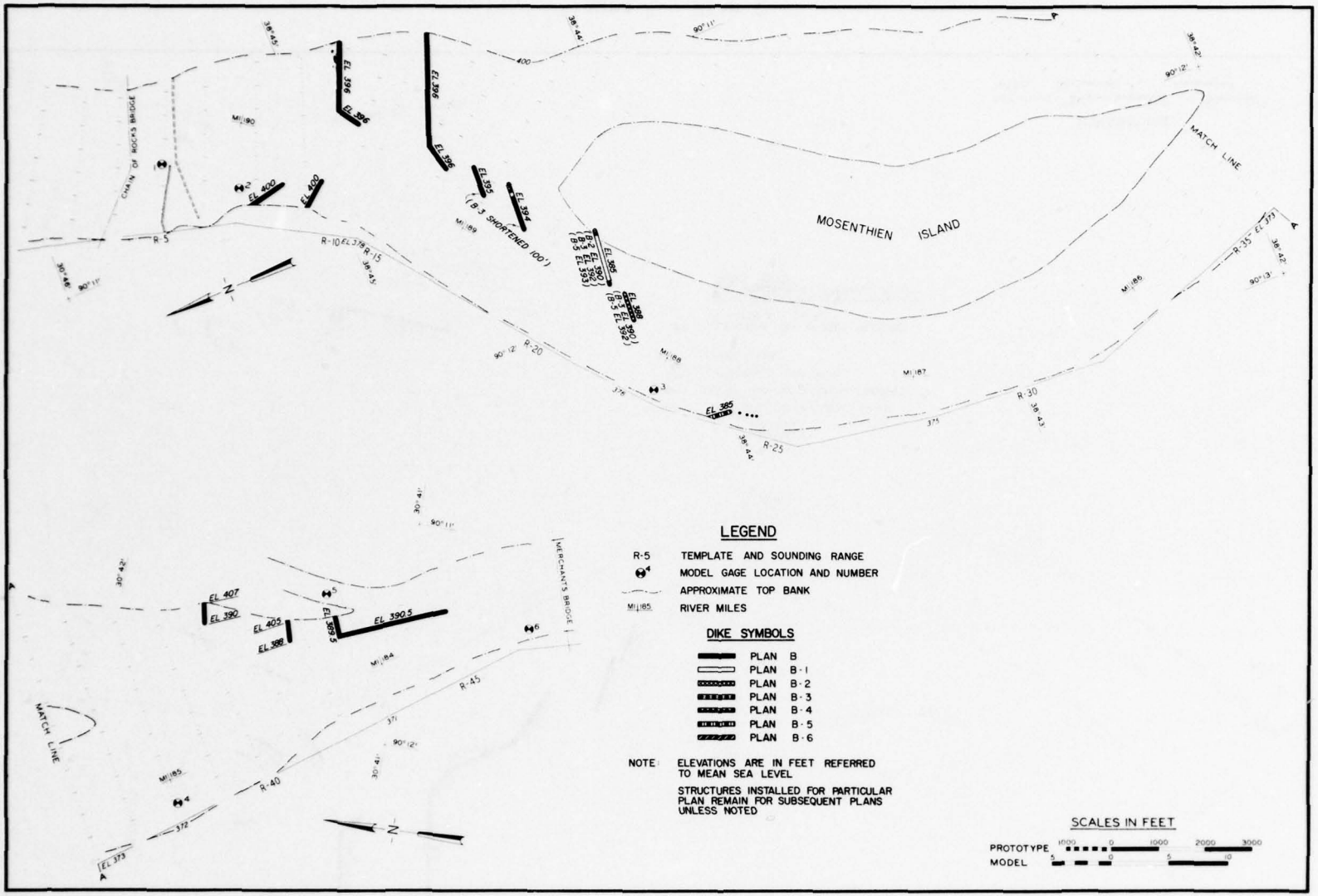


Figure 3. Plans B and B-1 through B-6

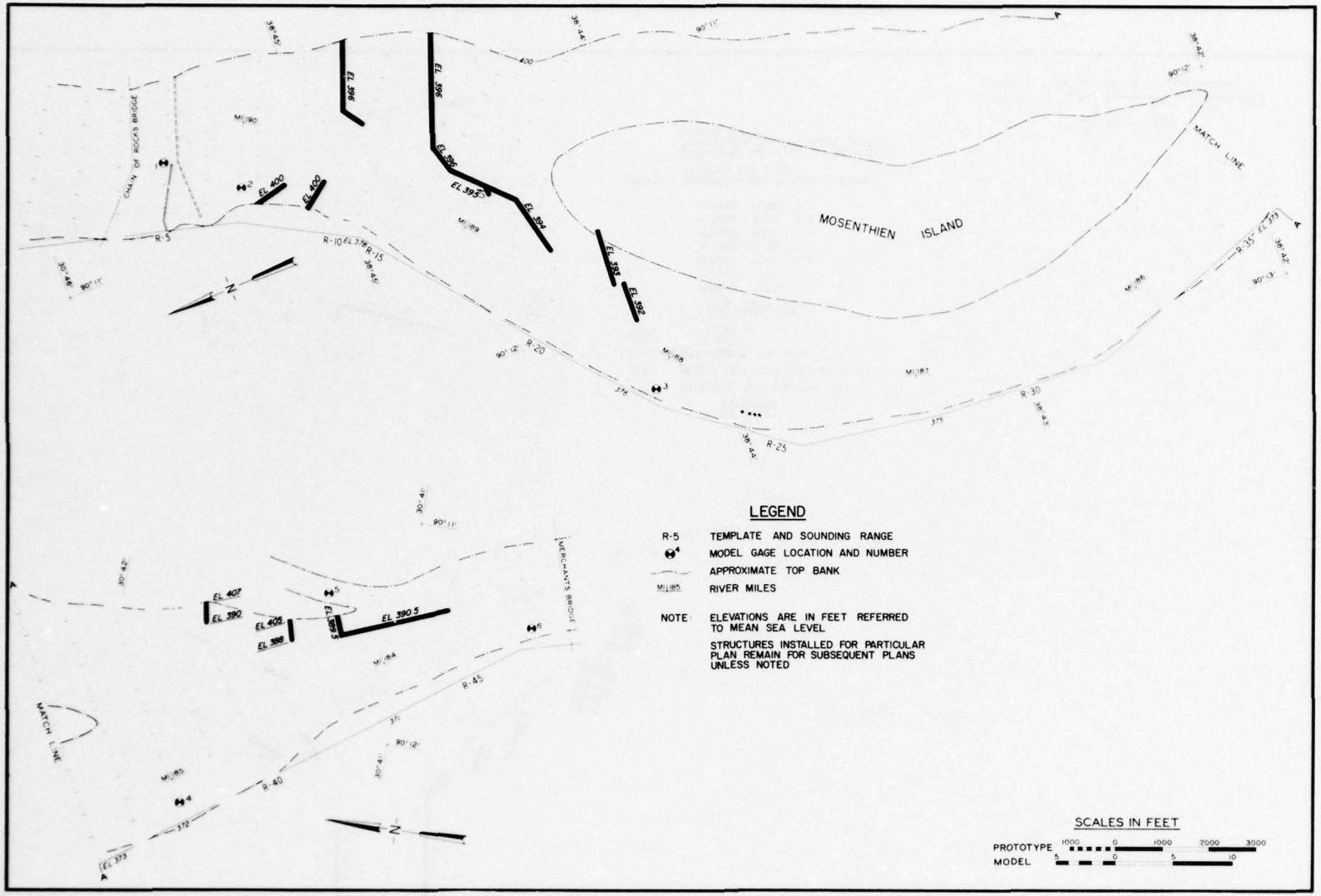


Figure 4. Plan C

channel downstream of the end of the spur dike at mile 189.2 caused by flow over the extension to the dike, and some shoaling occurred in the gap between the dike across the entrance to the chute channel and the head of Mosenthien Island.

Plans C-1 and C-2

Description

19. Plan C-1 involved the modification of the alignment of the dike across the entrance to the chute channel as shown in Figure 5. The change in the alignment of this dike had very little effect on channel development; therefore the results are not included. Plan C-2 was the same as plan C-1 except that the spur dike along Mosenthien Island at mile 188.4 was shortened 100 ft (Figure 5).

Results

20. Results of test of plan C-2 indicate that the crossing from the ends of the dikes near the head of Mosenthien Island toward the right bank increased to below project depth and the channel along the right bank in Sawyer Bend increased in width after one reproduction of the hydrograph (Plate 10). The channel along the right bank in Sawyer Bend extended farther upstream to about mile 188.0 and had more than adequate width. A shoal formed along the right bank between miles 186.3 and 185.9 but a channel of adequate depth was maintained to the left, a short distance from the bank. Considerable scouring developed along the left side of the dike across the entrance to the chute channel. After four reproductions of the hydrograph, the crossing at mile 188.0 had shoaled to less than project depth and the shoal along the right bank between miles 186.3 and 185.9 had increased in size and height.

Plan C-3

Description

21. Plan C-3 was the same as plan C-2 except for the installation of a 400-ft-long wing dike at the lower end of the trail dike at the

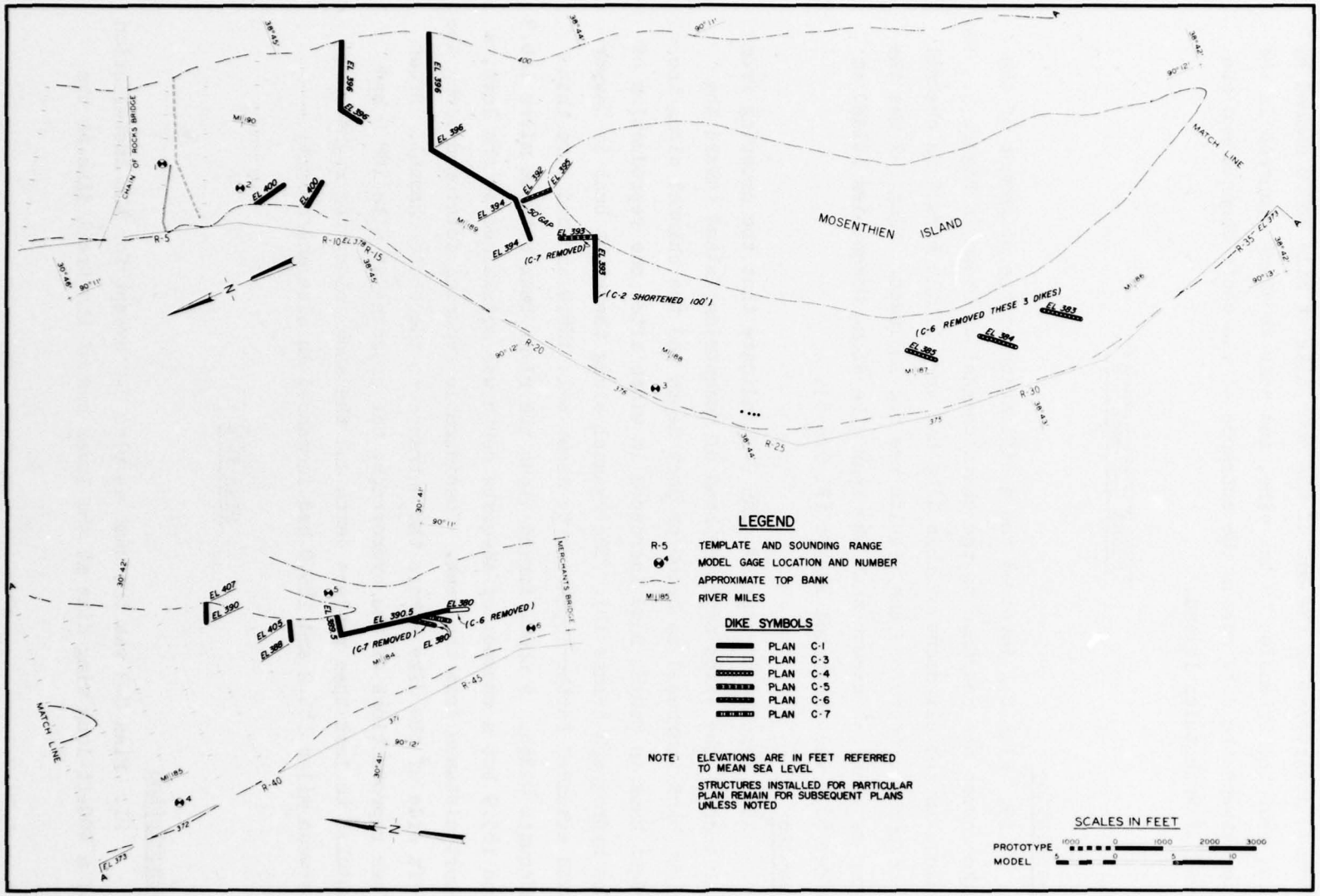


Figure 5. Plans C-1 through C-7

lower entrance to the Chain of Rocks Canal (Figure 5). The wing dike, designed to eliminate shoaling in the entrance to the canal during the lower flows, had a crest at el 380.0 and was angled 15 deg riverward.

Results

22. Results shown in Plate 11 indicate continued development in Sawyer Bend. The channel over the crossing from the dikes near the head of Mosenthien Island toward the right bank had shoaled to less than project depth. Along the right bank at mile 187.0 the channel tended to meander to the left, leaving a channel of less than project depth from that point downstream to about mile 186.0. Shoaling in the entrance to the Chain of Rocks Canal was eliminated during the one reproduction of the hydrograph.

Plans C-4, C-5, and C-6

Description

23. Plan C-4 involved the construction of three vane dikes between miles 187.0 and 186.4 in an effort to eliminate the tendency for the channel in Sawyer Bend to meander away from the right bank (Figure 5). Plan C-5 was the same as plan C-4 except for the addition of the spur dike extending upstream from the bank end of the spur dike at mile 188.4. The crest of the dike was at el 393.0. Plan C-6 was the same as plan C-5 except for the following (Figure 5):

a. The three vane dikes between miles 187.0 and 186.4 were removed.

b. A sloping dike was added at the head of Mosenthien Island extending upstream toward the dike across the entrance to the chute channel and leaving a 50-ft gap between the dikes. The new dike sloped from el 395.0 near the head of Mosenthien Island to el 393.0 at its upstream end.

c. The wing dike at the end of the trail dike at the entrance to the Chain of Rocks Canal was removed, and a wing dike was added along the river side of the trail dike about 900 ft upstream of the lower end. The crest of the dike was at el 380.0 and the dike was angled about 45 deg riverward of the trail dike. Before the start of test of plan C-6 the channel bed from mile 188.7 to 184.3 was remolded to the conditions obtained at the end of test of plan C-2 (Plate 10).

Results

24. Results of tests of plans C-4 and C-5 indicated continued deterioration of the channel in Sawyer Bend and, therefore, are not included herein. Results shown in Plate 12 indicate that with plan C-6 the crossing at mile 188.0 was about the same as that obtained at the end of the test of plan C-2 and deeper than that obtained at the end of test of plan C-3 (Plate 11). A channel of adequate width and depth was indicated along the right bank in Sawyer Bend downstream of mile 187.8; however, the channel tended to move away from the right bank at mile 186.5 with a shoal area forming along the bank between miles 186.5 and 186.0. Shoaling also occurred from the end of the trail dike at the lower entrance to the Chain of Rocks Canal to below the Merchants Bridge.

Plans C-7 and C-8

Description

25. Plan C-7 was the same as plan C-6 except that the dike extending upstream from the bank end of the dike along Mosenthein Island at mile 188.4 was removed and the wing dike along the river side of the trail dike at the lower entrance to the Chain of Rocks Canal was moved upstream 300 ft (Figure 5). Plan C-8 was the same as plan C-7 except for the following (Figure 6):

a. The wing dike along the river side of the trail dike at the lower entrance to the Chain of Rocks Canal was removed and a 400-ft wing dike was added off the end of the trail dike. The wing dike was angled riverward 15 deg and had a crest at el 380.0.

b. Two 1000-ft-long vane dikes were placed along the left side of the channel about mile 186.5 with crests at el 387.0 for the upstream dike and el 340.0 for the downstream dike.

c. A spur dike extending from the river side of Mosenthien Island was added at mile 187.0 with crest at el 390.0.

Results

26. Results of tests which are not shown in the plates indicated that with plan C-7 the crossing at mile 188.0 would shoal to less than

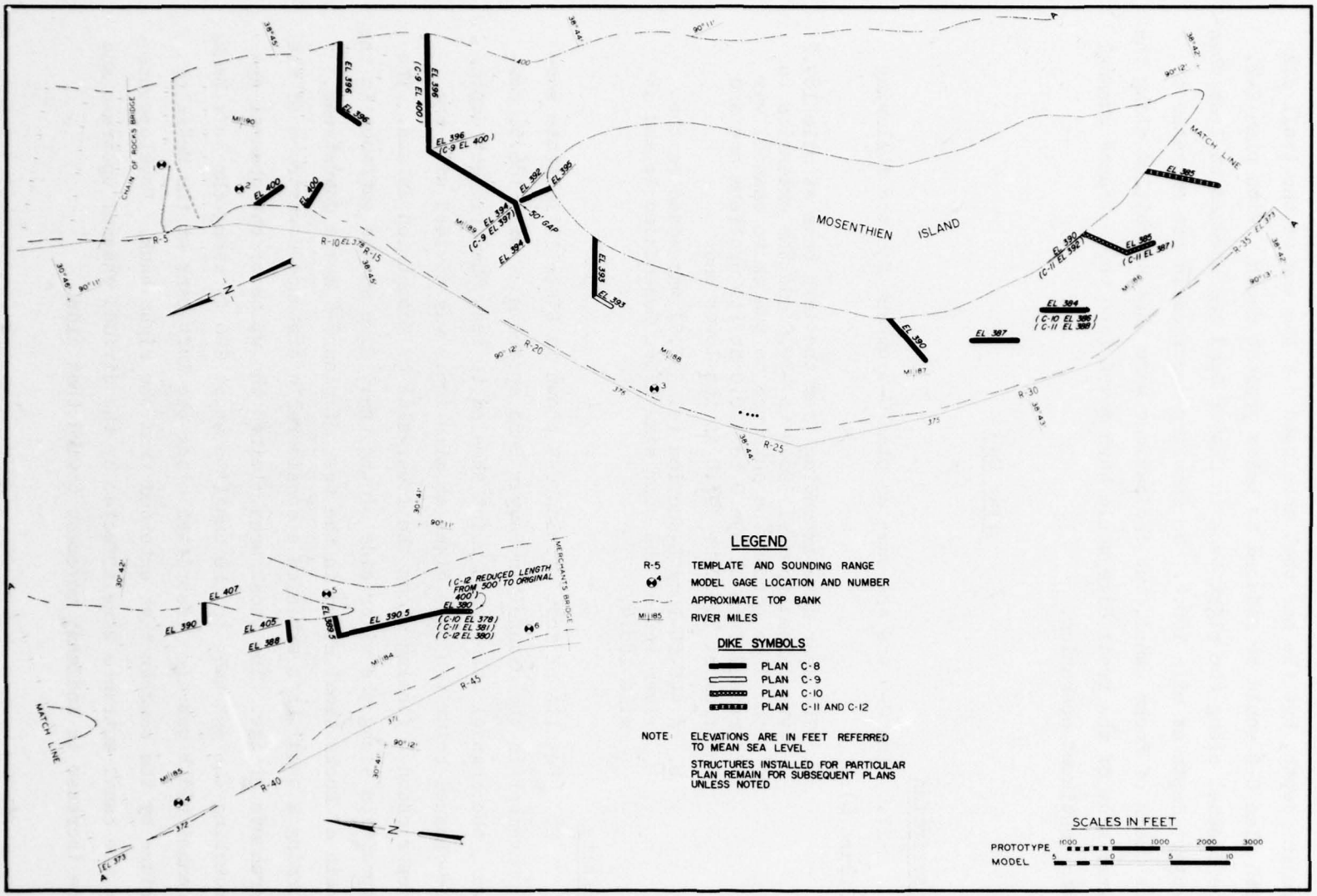


Figure 6. Plans C-8 through C-12

project depth, but the bar that developed off the end of the trail dike with plan C-6 would be reduced to below project depth. With plan C-8, the channel along the right bank in Sawyer Bend had shoaled to less than project depth at mile 186.4. No shoaling occurred in the entrance to the Chain of Rocks Canal, but indications were that deposition along the river side of the trail dike would have moved into the entrance channel with continued operation.

Plan C-9

Description

27. Plan C-9 was the same as plan C-8 except for the following (Figure 6):

a. The spur dike extending from the left bank at mile 189.2 was raised from el 396.0 to 400.0 and the extension to the dike across the entrance to the chute channel was raised from el 396.0 to 400.0 at its upstream end and from el 394.0 to 397.0 at its lower end.

b. A 400-ft-long L-section (el 393.0) was added on the river end of the spur dike along Mosenthien Island at mile 188.4.

Results

28. Results of test of plan C-9 shown in Plate 13 indicate some improvement in the channel in Sawyer Bend upstream of mile 186.5; however, the channel below that point shoaled to less than project depth. The channel below the vane dikes at mile 186.2 was divided with the deeper channel forming along the lower side of Mosenthien Island. The deposition along the river side of the trail dike at the entrance to the Chain of Rocks Canal noted in the test of plan C-8 moved downstream, forming a shoal that extended a considerable distance downstream of the Merchants Bridge. The shoal area limited the width of the channel approaching the entrance to the canal to about 200 ft along the left bank. Channel width was also restricted along the left bank at the McKinley Bridge by the sandbar that extended from the right bank. Developments in the canal entrance were affected by the divided channel upstream and the increase in sediment movement toward that side.

Plans C-10 and C-11

Description

29. Plan C-10 was the same as plan C-9 except that:

a. The vane dike at mile 186.3 was raised to el 386.0.

b. A spur dike with crest sloping from el 390.0 at the bank end to el 385.0 with an L-head section at el 385.0 was installed at mile 186.0.

c. The wing dike at the end of the trail dike at the entrance to the Chain of Rocks Canal was extended 100 ft and its crest lowered to el 378.0 (Figure 6).

30. Plan C-11 was the same as plan C-10 except that (Figure 6):

a. The vane dike at mile 186.3 was raised to el 388.0.

b. The spur dike with the L-head section at mile 186.0 was raised 2 ft.

c. A spur dike with crest at el 385.0 was installed along Mosenthien Island at mile 185.6.

d. The wing dike at the end of the trail dike at the lower entrance to the Chain of Rocks Canal was raised to el 381.0.

Results

31. Results of plans C-10 and C-11 are not shown in the plates since an adequate channel had not been developed. There was some improvement in the channel in Sawyer Bend, particularly with plan C-11, but a channel of adequate depth was not obtained downstream of the dikes along the left bank. There was some decrease in the shoaling in the lower entrance to the Chain of Rocks Canal with plan C-11. Although there was some increase in the width of the channel along the left bank near the McKinley Bridge, the width was limited to about 250 ft.

Plan C-12

Description

32. Plan C-12 was the same as plan C-11 except that the wing dike at the end of the trail dike at the lower entrance to the Chain of Rocks Canal was shortened 100 ft and its crest lowered 1 ft to el 380.0. This plan was tested with two reproductions of the test hydrograph (Plate 4).

Results

33. Results shown in Plate 14 indicate that a channel of adequate width and depth had developed along the right bank in Sawyer Bend. The channel upstream of mile 187.0 remained satisfactory for five hydrographs (plans C-9 through C-12), indicating a satisfactory solution to shoaling in this reach. The channel had moved away from the bank at mile 185.5 and a shoal area that formed along the bank extended as much as 400 ft from the bank. Little or no shoaling occurred in the entrance to the canal except for a small area with depths about 1 ft less than project depth. The shoal area near the McKinley Bridge was also reduced considerably, leaving only a narrow strip of less than project depth.

Plan D

Description

34. The prototype survey of June 1973 (including portions of the reach surveyed in October-November 1973), shown in Plate 15, indicated that there had been considerable erosion of the head of Mosenthien Island during the 1973 flood. Conditions, therefore, were considerably different from those indicated by the March 1971 survey, particularly with regard to the location and alignment of the head of the island and in the distribution of flow that had increased in the chute channel to the left. Also, shoaling in Sawyer Bend had increased, leaving a channel of project depth only in the reach between miles 187.3 and 185.6.

35. Because of these changes, tests based on the March 1971 conditions were discontinued and the model was remolded to the conditions indicated by the June 1973 survey. For plan D only the existing structures were installed in the model and these were modified as proposed by LMS. The features of plan D (Figure 7) were as follows:

a. The existing dike at mile 189.6 was restored to el 399.0 and an L-head section added to the end of the dike at the same elevation.

b. The existing dike at mile 189.3 was restored to el 397.0 and an L-head section added at the end of the dike with the crest sloping from el 397.0 to 393.0 on its downstream end.

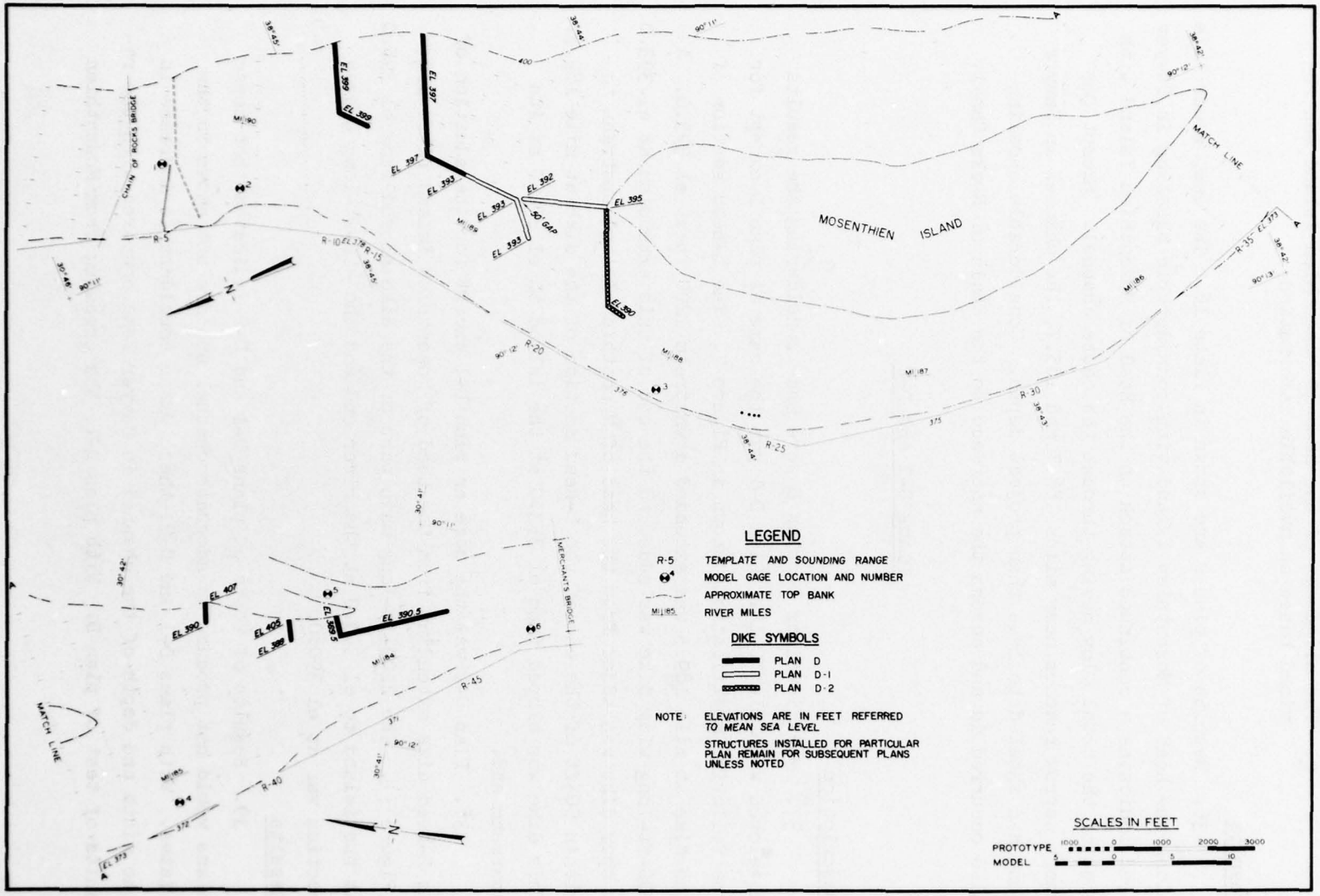


Figure 7. Plans D, D-1, and D-2

c. The alignment of the head of Mosenthien Island was revised based on available information.

Results

36. Results of plan D are shown in Plate 16. The deep scour hole along the head of Mosenthien Island with considerable shoaling in Sawyer Bend indicates a continued attack on the head of Mosenthien Island with most of the total flow moving through the chute channel. Except for short narrow reaches near miles 186.7 and 185.7, the channel in Sawyer Bend had shoaled to less than project depth. Considerable shoaling also occurred in and across the entrance to the Chain of Rocks Canal.

Plans D-1 and D-2

Description

37. Modifications to plan D were made considering the results developed with plan C-12. Plan D-1 was the same as plan D except for the following modifications shown in Figure 7. The L-head section of the dike at mile 189.3 was extended downstream 1200 ft at el 393.0. A 900-ft-long wing dike was added to the end of this extension at el 393.0. A spur dike was added from the head of Mosenthien Island upstream to within 50 ft of the end of the L-head section of the dike at mile 189.3. This dike was sloped from el 393.0 at the island to el 392.0 at its upstream end.

38. Plan D-2 was the same as plan D-1 except for the addition of an L-head dike extending from the head of Mosenthien Island riverward (Figure 7). The 2100-ft-long main part of the dike sloped from el 395.0 at the island to el 390.0 at the river end and the 450-ft-long L-head section was at el 390.0.

Results

39. Results of tests of plans D-1 and D-2 indicated that these plans would not produce an adequate channel and are not shown in the plates. With plans D-1 and D-2, there was a considerable increase in the width and depth of the channel in Sawyer Bend compared with the results of test of plan D. With plan D-1, the crossing from Mosenthien

Island toward the right bank was about a mile farther downstream than desired. The L-head dike of plan D-2 shifted the channel to the right, but the channel moved back to the left toward Mosenthien Island before crossing toward the right bank.

Plan D-3

Description

40. Plan D-3 was the same as plan D-2 except for the following (Figure 8):

a. The wing dike at mile 188.8 was shortened 100 ft.

b. The length of the main portion of the dike at the head of Mosenthien Island (mile 188.5) was reduced 400 ft and the L-head section was extended 350 ft and angled more to the right.

Results

41. Results shown in Plate 17 indicate that the modifications included in this plan were not effective in developing a satisfactory crossing toward the right bank. There was a strong tendency for the channel to cross back toward the left and along Mosenthien Island just downstream of the dike system as with plan D-2. There was some increase in the depth and width of the channel in Sawyer Bend below the crossing. Shoaling continued in the lower entrance to the Chain of Rocks Canal but the deposition was not as much as that with plan D.

Plans D-4, D-5, and D-6

Description

42. Plans D-4, D-5, and D-6 were modifications of plan D-3 designed to eliminate the tendency for the channel to meander toward the right side of Mosenthien Island after passing the ends of the dikes near the head of the island. The features of these plans were as follows (Figure 8):

a. Plan D-4. The spur dike at mile 189.3 was raised from el 397.0 to 400.0 and the L-head section of this dike

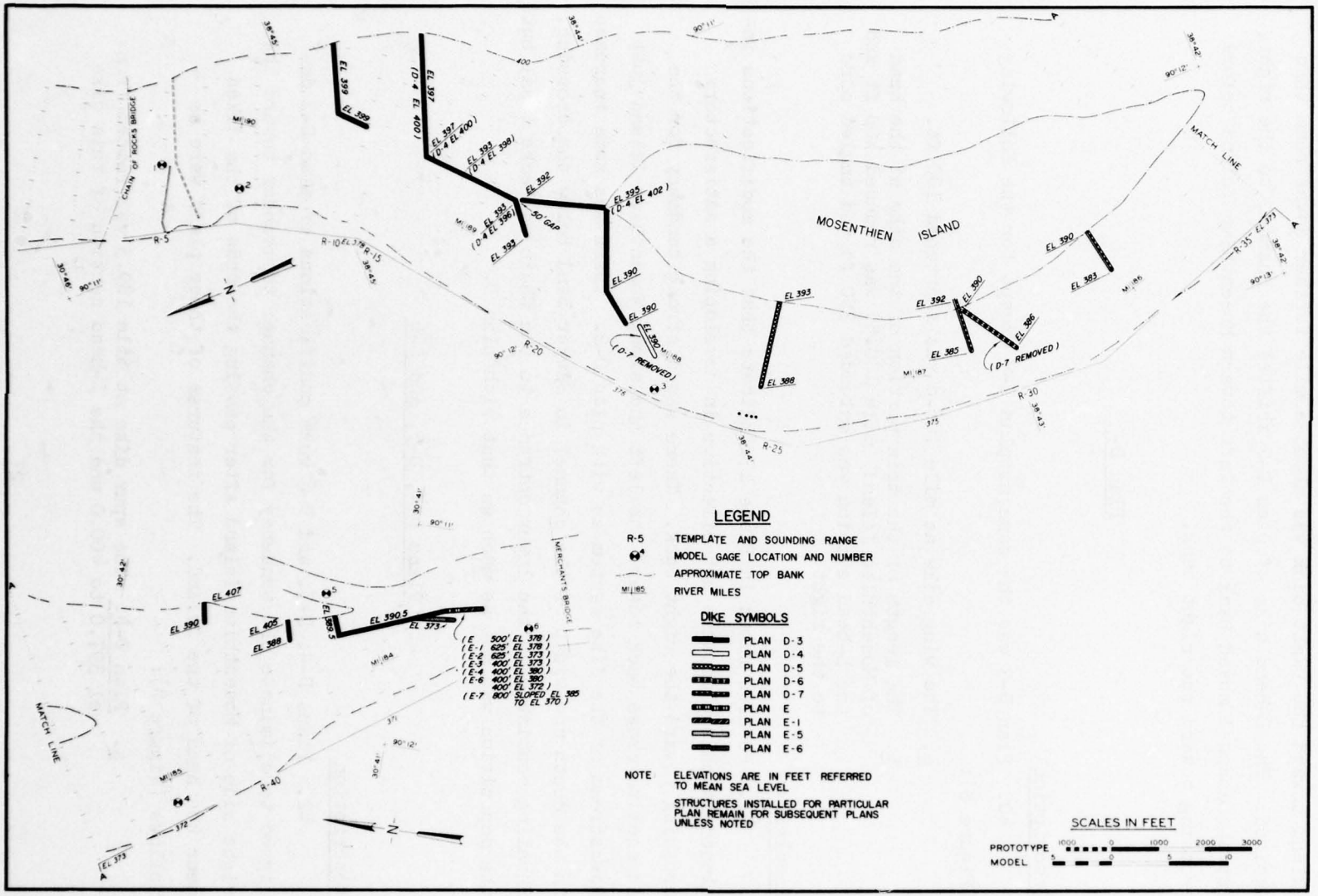


Figure 8. Plans D-3 through D-7, Plan E, and Plans E-1 through E-6

was raised to el 400.0 at the upstream end and to el 396.0 at its downstream end. The two dikes at the head of Mosenthien Island were raised from el 395.0 to 402.0 at the island ends, and an 800-ft-long vane dike was added just downstream of the L-head section of the dike at mile 188.3.

b. Plan D-5. A 1900-ft-long dike was added along the right side of Mosenthien Island at mile 187.6. The crest of the dike sloped from el 393.0 near the island to el 388.0 in the channel.

c. Plan D-6. A 1600-ft-long dike was added along the right side of Mosenthien Island at mile 186.6. The dike was angled toward the downstream with a crest sloping from el 390.0 at the island to el 386.0 in the channel.

Results

43. Results of tests of plans D-4 to D-6 are not shown in the plates. Progressive improvements were obtained in the channel along the right bank in Sawyer Bend with the modifications tested. With plans D-4 and D-5 the channel still tended to meander to the left, particularly with plan D-4. With plan D-6, a channel of more than adequate width and depth was obtained along the right bank in Sawyer Bend extending downstream from about mile 188.0. Shoaling in the lower entrance to the Chain of Rocks Canal continued with the three plans.

Plan D-7

Description

44. Plan D-7 was the same as plan D-6 except for the following (Figure 8):

a. The vane dike at mile 188.1 was removed.

b. The dike at mile 186.6 was replaced with a shorter dike normal to the channel alignment. The dike sloped from el 392.0 at the island to el 385.0 in the channel.

c. A dike was added along Mosenthien Island at mile 186.0. The dike sloped from el 390.0 near the island to el 383.0 in the channel.

Results

45. Results shown in Plate 18 indicate than an adequate channel

was maintained along the right bank in Sawyer Bend extending as far upstream as mile 188.0. Scouring was indicated downstream of the dike at mile 189.3 and on the chute side of the L-head section. This condition was indicated by all of the tests with dikes across the entrance to the chute channel. The depth of scour would depend on the elevation of bedrock in the area and on the elevation of the dikes.

46. A shoal area formed along the right bank between miles 184.5 and 183.6 with the deep channel maintained along the right side of the trail dike at the lower entrance to the Chain of Rocks Canal. Shoaling occurred in the approach to the lower entrance to the Chain of Rocks Canal which extended from a short distance downstream of the end of the trail dike to just above the McKinley Bridge. A narrow channel of adequate depth was maintained along the bank to the left of the shoal.

Plans E, E-1, E-2, E-3, E-4, E-5, E-6, and E-7

Description

47. Plan E and modifications were designed to reduce or eliminate shoaling in the lower entrance to the Chain of Rocks Canal and the approach to this entrance. The existing trail dike has been successful in eliminating most of the shoaling in the entrance channel when it is overtopped. Most of the shoaling occurs during low flows when the sudden increase in channel width causes the slower moving currents to move into the approach to the canal. When the trail dike is overtopped, surface flow over the top reduces or eliminates the lateral differential in water level near the end of the dike, thus preventing the sediment-laden bottom currents from moving into the entrance. Plans were designed to reduce the lateral differential during the lower flows by permitting surface flows to move into the approach. Conditions for these tests were the same as those for test of plan D-7 except for the following modifications near the lower entrance to the canal (Figure 8):

a. Plan E. A 500-ft-long wing dike was placed at the end of the trail dike. The dike had a crest el of 378.0 and was angled 12 deg to the right.

b. Plan E-1. The length of the wing dike of plan E was increased to 625 ft.

c. Plan E-2. The height of the wing dike of plan E-1 was lowered 5 ft to el 373.0.

d. Plan E-3. The length of the wing dike of plan E-2 was shortened to 400 ft.

e. Plan E-4. The height of the wing dike of plan E-3 was raised 7 ft to el 380.0.

f. Plan E-5. A 500-ft-long wing dike was added along the right side of the trail dike about 750 ft upstream of the end of the dike. The crest of the dike was at el 373.0.

g. Plan E-6. The wing dike at the end of the trail dike was extended 400 ft with the crest of the extension at el 372.0 and the wing dike along the right side of the trail dike was extended 150 ft at el 373.0.

h. Plan E-7. The wing dike at the end of the trail dike was sloped from el 385.0 at trail dike end to el 370.0 at its downstream end.

Results

48. The more significant results obtained with plan E and modifications are shown in Plates 19 and 20. These results indicate that plan E was more effective than any of the modifications. With plan E, only a small area with depths of 1 to 2 ft less than project depth was indicated. Also, the shoal area along the right bank opposite the trail dike (mile 184.0), noted in the test of plan D-7, was reduced considerably in size. Lengthening of the wing dike in plan E-1 caused sediment to move over the top of the wing dike and increased shoaling in the canal entrance considerably. Lowering the elevation of the wing dike as in plan E-2 caused an increase in the shoaling along the left bank just downstream of the end of the trail dike. Shortening of the length of the low wing dike in plan E-3 increased the amount and area of shoaling along the left bank. With the elevation of the wing dike raised in plan E-4, some of the shoal that was developed with plan E-3 was eroded but the shoal area extended farther downstream.

49. The addition of a second wing dike upstream of the end of the trail dike in plan E-5 resulted in shoaling of the channel to the right of the trail dike (mile 184.0) to less than project depth and shoaling along the left bank downstream of the end of the trail dike

from mile 183.4 to 183.0. Extension of the two wing dikes in plan E-6 reduced the shoal area obtained with plan E-5 considerably but increased the size of the shoal area farther downstream. A channel of project depth developed along the right side of the trail dike (mile 184.0) but the channel was narrow and of poor alignment.

50. Modification of the wing dike to a sloped crest in plan E-7 caused shoaling along the right side of the approach extending from just off the end of the wing dike to the McKinley Bridge (Plate 20). Some shoaling occurred along the left bank at about mile 183.0 but a channel of adequate width and depth was maintained. The channel to the right of the shoal below the end of the trail dike was narrow near the McKinley Bridge and could affect navigation toward Sawyer Bend. A channel of adequate width and depth was maintained along the right bank in Sawyer Bend downstream to mile 185.4 for 10 hydrographs (plans D-6 through E-7), indicating a stable channel. However, the channel moved to the left at mile 185.4 and remained away from the right bank downstream of the upper end of the trail dike.

Plans F, F-1, F-2, F-3, and F-4

Description

51. Plans F and modifications were concerned with the improvement of the channel in the lower end of Sawyer Bend and with shoaling in the lower entrance to the Chain of Rocks Canal. Plan F was the same as plan E-7 except that a sloping crest dike along Mosenthien Island was added at mile 185.3 with el 392.0 near the island and sloping to el 381.0 in the channel; the wing dike on the end of the trail dike was shortened 400 ft and its crest was level at el 380.0; and the wing dike along the right side of the trail dike was removed (Figure 9).

a. Plan F-1. The length of the dike at mile 185.3 was reduced 150 ft and the length of the dike at mile 186.0 was increased 275 ft (Figure 9).

b. Plan F-2. The wing dike at the end of the trail dike at the canal entrance was extended downstream 500 ft at el 367.0 parallel to the canal approach channel (Figure 9).

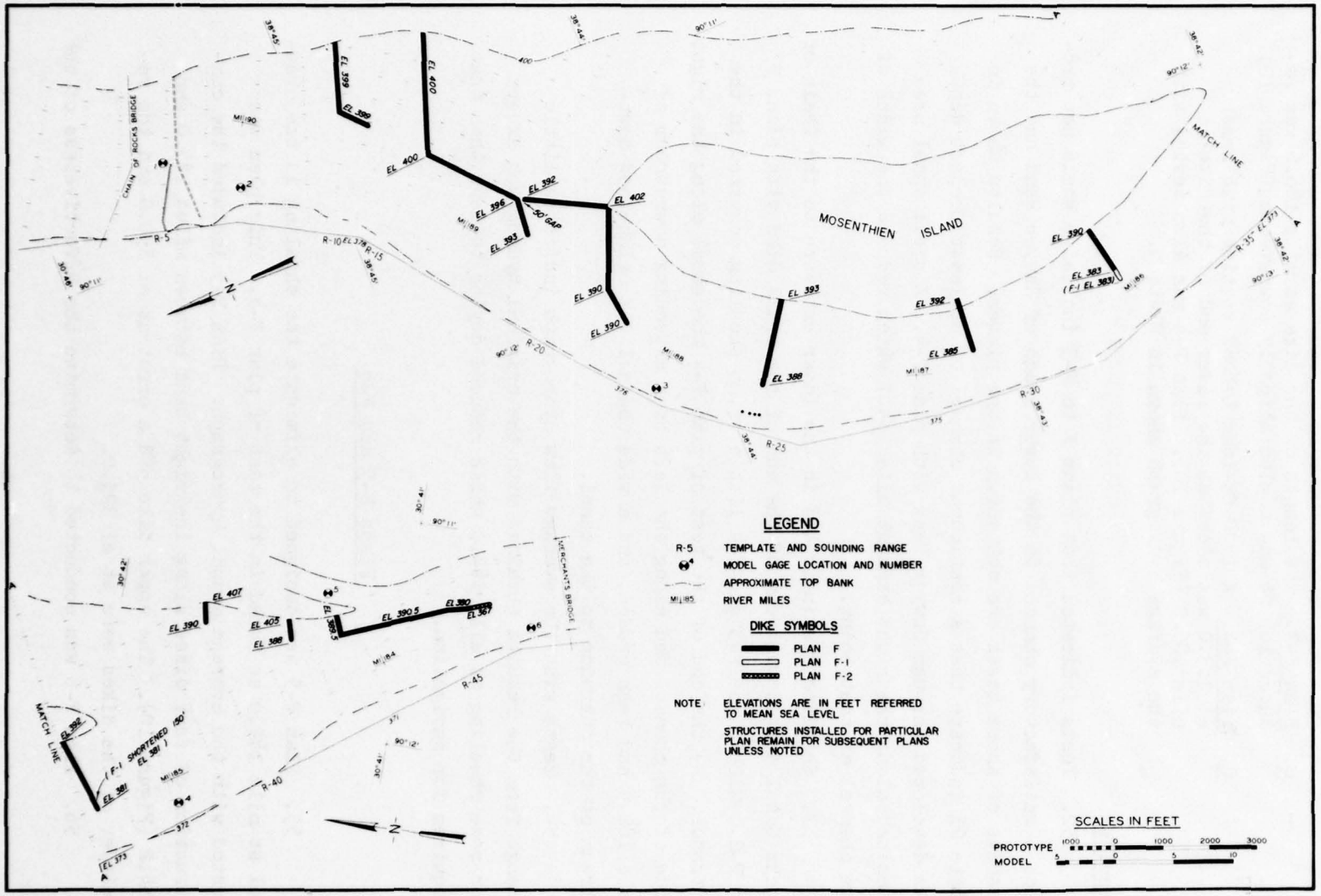


Figure 9. Plans F, F-1, and F-2

c. Plan F-3. The length of the dike at mile 186.0 was reduced 100 ft and angled slightly downstream (Figure 10).

d. Plan F-4. A 1000-ft-long L-head section with crest el 383.0 was added at the river end of the dike at mile 186.0 (Figure 10). Plan F-4 was also tested with the average hydrograph shown in Plate 5.

Results

52. Tests indicated that plans F to F-3 inclusive would not produce a satisfactory channel in the lower reach of Sawyer Bend and the results of these tests are not shown in the plates. Results shown in Plate 21 indicate that a continuous channel of at least project depth was developed through Sawyer Bend with plan F-4. A small shoal area remained along the right bank at mile 184.7 which reduced the width of the channel at that point.

53. Shoaling was indicated in the lower entrance to the Chain of Rocks Canal just downstream of the end of the trail dike with plans F to F-2. With plans F-3 and F-4 little or no shoaling occurred in the entrance. By the end of the test of plan F-4 the shoal along the right side of the channel and along the left bank extending downstream of mile 182.9 had been eroded, and a wide channel was maintained downstream of the entrance to the canal.

54. Tests with the average flow hydrograph indicated little change from the results obtained with the original hydrograph except for some shoaling at mile 184.0 which reduced depths to less than that required for navigation.

Plans F-5 and F-6

55. Plan F-5 was designed to eliminate the shoaling in the channel at mile 184.0 as noted in the test of plan F-4. This plan was tested with the average annual hydrograph. Plan F-5 included the construction of four dikes along the right bank between miles 185.0 and 184.2 (Figure 10). The upper dike had a crest at el 390.0 and the remainder of the dikes were at el 395.0.

56. Plan F-6 was conducted to determine the effectiveness of the

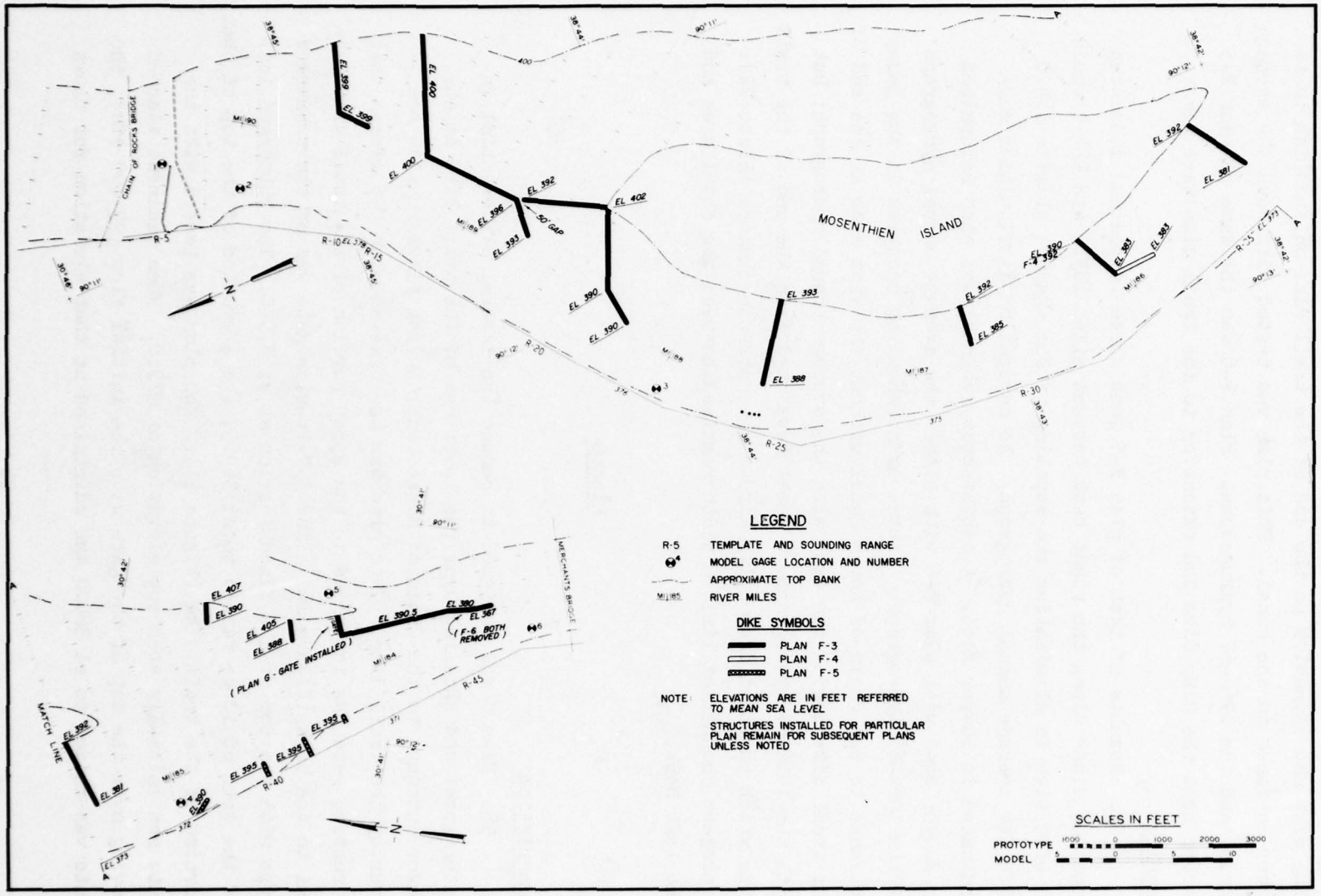


Figure 10. Plans F-3 through F-6 and plan G

wing dike and extension on the end of the trail dike on shoaling in the lower entrance to the canal. This plan was tested with both the average annual and the 1966-67 hydrographs. Plan F-6 was the same as plan F-5 except that the wing dike and extension to the trail dike were removed.

Results

57. Results of test of plan F-5 (not shown in plates) indicated that the dikes along the right bank between miles 185.0 and 184.2 would be effective in eliminating the shoaling of the channel at mile 184.0 with the average annual hydrograph. No navigation difficulties were indicated in Sawyer Bend. A satisfactory channel was also maintained in Sawyer Bend with plan F-6 with either the average annual hydrograph or the 1966-67 hydrograph. Little or no shoaling occurred in the lower entrance to the Chain of Rocks Canal without the wing dike at the end of the trail dike during the test with the average annual hydrograph; but with the 1966-67 hydrograph, a shoal developed from the end of the trail dike which extended diagonally across the entrance channel (Plate 22). A project channel of limited width remained between the shoal area and the left bank.

Plan G

Description

58. Plan G was designed to reduce the lateral differential in water level and shoaling near the lower end of the trail dike at the lower entrance to the Chain of Rocks Canal during flows that do not overtop the trail dike. This plan was the same as plan F-6 except that a control gate was installed in the upper portion of the trail dike normal to the bank (Figure 10). The 350-ft-wide gate was of the submerged type with the top of the fixed section at el 375.0. The submerged leaf of the gate could be raised to el 389.5, the elevation of the top of that portion of the trail dike (Figure 11). The plan was tested with the gate set initially at a top elevation of 375.0. When sediment started moving over the top of the gate with the initial flow (93,000 cfs), the gate was raised to el 380.0 and maintained at that elevation for flows

up to a discharge of 213,900 cfs at which time the gate was raised to el 389.5 (top of the trail dike). During the falling stages, the gate was lowered to el 380.0 with discharges of 164,000 cfs and less.

Results

59. Results of the test of plan G after two reproductions of the 1966-67 hydrograph shown in Plate 22 indicate no shoaling in the entrance to the canal. The success of this plan would depend on the operation of the gate. When stages are substantially higher than the top of the trail dike, sufficient surface flows move over the top of the dike. This causes some scour on the entrance side of the dike and prevents bottom currents from moving into the canal approach from the river side. During low flows, the movement of bottom currents around the end of the trail dike can be prevented by lowering the gate and permitting sufficient sediment-free flow into the canal approach. If the gate is too low, sediment will move over the gate and be deposited in the canal entrance. Operation of the gate in the trail dike had little effect on the channel to the right of the trail dike.

Plan H

Description

60. Plan H consisted of the first phase of construction proposed by LMS for the improvement and stabilization of the reach. This plan, based on the results of the tests completed, included the following (Figure 11):

a. The existing dikes upstream of Mosenthien Island miles 189.6 and 189.3 were installed to el 400.0 and 399.0, respectively.

b. An 800-ft-long L-head section was added to the dike at mile 189.6 to el 400.0 and a 2000-ft-long L-head section was added to the dike at mile 189.3. The upper 800 ft of the L-head on the dike at mile 189.3 was at el 399.0 and the remainder at el 397.0.

c. A 2000-ft-long dike was installed that extended from the head of Mosenthien Island upstream, leaving an opening of 600 ft between that dike and the L-head section on the dike at mile 189.3. The first 1320 ft from the

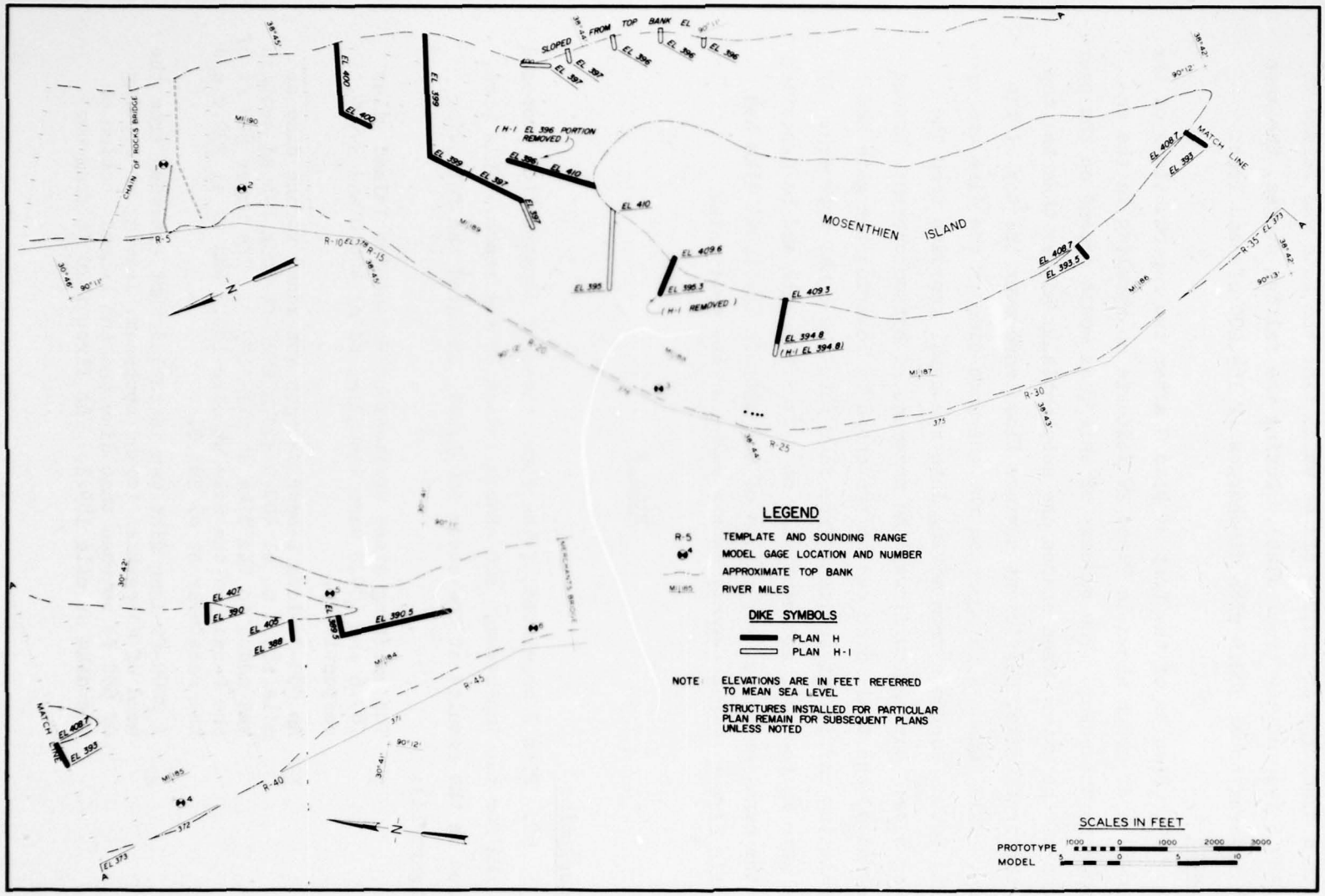


Figure 11. Plans H and H-1

island was at el 410.0 and the remainder upstream was at el 396.0.

d. Sloping crest dikes were installed along the channel side of Mosenthien Island at miles 188.2, 187.6, 186.0, and 185.4. The bank ends of these dikes were at el 409.6, 409.3, 408.7, and 408.7, and the river ends were at el 395.3, 394.8, 393.5, and 393.0, respectively.

61. Before installation of the plan, the bank line of Mosenthien Island was modified to conform with the prototype survey of 23 May 1975. The gate in the trail dike at the entrance to the Chain of Rocks Canal was in the raised position simulating existing conditions. After the reproduction of two hydrographs, the bed of the model was remolded to the prototype survey of June 1973 (Plate 15) and the test was repeated with two additional reproductions of the hydrograph.

Results

62. Results of test of plan H with the first two reproductions of the hydrograph indicated that an adequate channel was developed along the right bank in Sawyer Bend except at mile 184.0 where a shoal area extending from the lower end of Mosenthien Island reduced the width of the channel along the right bank. Repetition of the test with the bed remolded to the 1973 conditions indicated a satisfactory channel in Sawyer Bend and downstream as shown in Plate 23. The shoal area noted in the initial test did not develop with the 1973 conditions. The channel near the head of Mosenthien Island was directed toward the bank end of the dike at mile 188.2, causing it to be under a strong attack with scouring down to bedrock along the downstream side of the dike. Considerable scouring also occurred along the right side of the dike extending upstream from the head of the island and along the left bank in the chute channel at mile 189.0 and mile 187.5.

Plan H-1

Description

63. Plan H-1 was the same as plan H except for the following modifications (Figure 11):

a. The dike at mile 188.2 and the upstream 680 ft of the dike extending from the head of Mosenthien Island were removed.

b. A 700-ft dike angled 45 deg riverward was added on the end of the L-head section of the dike at mile 189.3. The crest of the addition was at el 397.0, the same as the L-head section.

c. A 1750-ft-long dike angled about 30 deg toward the downstream was installed along the river side of Mosenthien Island at mile 188.5. The dike sloped from el 415.0 at the island to el 397.0 in the channel.

d. The dike along Mosenthien Island at mile 187.6 was extended 250 ft.

e. Five dikes were added along the left bank in the chute channel between miles 189.1 and 188.5.

Results

64. Results shown in Plate 24 indicate considerable deterioration of the channel in Sawyer Bend after one reproduction of the hydrograph compared with the conditions obtained with plan H. Only a narrow channel was obtained along the right bank between miles 187.7 and 186.9 and at mile 185.0. Some scour occurred along Mosenthien Island downstream of the dike at mile 188.5 and between the L-head section to the dike at mile 189.3 and the dike at the head of Mosenthien Island. Shoaling also occurred in the lower entrance to the Chain of Rocks Canal extending from the end of the trail dike toward the left bank.

65. Plan H-1 forced the channel near the entrance to the chute channel to the right, causing considerable erosion of the large sandbar along the right bank at mile 188.5. The material eroded from the sandbar moved downstream and contributed to the deterioration of the channel along the right bank. The alignment of the crossing toward the right bank was considerably better than that with plan H and occurred somewhat farther upstream. Indications are that continuing the test beyond the reproduction of one hydrograph would have produced a satisfactory channel along the right bank in Sawyer Bend.

PART IV: DISCUSSION OF RESULTS AND CONCLUSIONS

Interpretation of Model Results

66. In an analysis and evaluation of the results of this study the limitations of the model based on the model verification, base test, hydrographs used, and condition of the model bed at the time that a plan or modification was installed should be considered. Developments within the reach would be affected by the elevation of bedrock, flow conditions (particularly discharge from the Missouri River which affects the amount of sediment in the reach), and the time when the model survey is made with respect to the flow hydrograph. The model was constructed based on the best information available at the time and was later modified based on the 1973 and 1975 prototype surveys which indicated changes in the location and shape of the head of Mosenthien Island that affected the distribution of flow around the island. Bedrock in the reach was based on an old small-scale map that was subject to several interpretations because of the limited detail.

67. Flow condition is also an important factor in development within the reach, particularly as it affects shoaling in the lower entrance to the Chain of Rocks Canal. During high flows that overtop the trail dike at the entrance to the Chain of Rocks Canal, the shoal in the entrance tended to erode, leaving only some mud and fine silt between the end of the dike and the canal entrance. During low-flow periods, shoaling develops because of the sudden increase in channel width downstream of the trail dike. The shoal could extend downstream to below the Merchants Bridge. Shoaling in the lower entrance to the canal would also be affected by changes in the channel upstream. In many of the tests described herein, changes in plans produced changes in the channel and movement of sediment from upstream which could have affected developments in the approach to the canal; the results from those tests therefore would not necessarily be conclusive.

68. The 1966-67 stage hydrograph reproduced in the test of plans included about seven months of flows that did not overtop the trail dike

at the lower entrance to the Chain of Rocks Canal at the beginning of the test. However, the model survey was always made after there had been only about 40 days when the trail dike was not overtopped following a high-water period with a peak river stage of about 18 ft above the top of the structure. Accordingly, the amount of shoaling in the lower entrance to the canal at the time of the model survey would tend to be considerably less than it would be had the survey been made at the end of a long low-water period.

69. Although the adjustment of the model was considered adequate, the limitations of the model in reproducing all the factors affecting developments in the reach and the differences between the model and prototype indicated by the results of the verification test have to be considered in the evaluation of model results. The model did not reproduce sediment moving in suspension or the erosion of riverbanks which were fixed in the model. In spite of the limitations mentioned, the adjustment of the model was sufficient to indicate the trends that can be expected under the conditions imposed for each plan or modifications and the relative effectiveness of such plans.

Summary of Results and Conclusions

70. The indications and conclusions developed from the results of the model tests are summarized as follows:

a. Most of the sediment out of the Missouri River tends to move along the right bank for a considerable distance downstream, contributing to the development of the sandbar along the bank opposite the entrance to the chute channel to the left of Mosenthien Island and to shoaling of the channel in Sawyer Bend.

b. Development of the channel in Sawyer Bend is affected by the distribution of flow around Mosenthien Island. Development of the sandbar opposite the entrance to the chute channel had forced the deep channel to the left against the island, causing some increase in flow through the chute channel and erosion of the head of the island by the time of the March 1971 survey. During the 1973 high water, portions of the two dikes upstream of Mosenthien Island, designed to prevent the development of the chute channel, were destroyed and several hundred feet of the upstream portion of the island was eroded. The

effects of these changes was an increase in the discharge through the chute channel (up to about 70 percent of the total) and increased shoaling in the channel to the right of the island in Sawyer Bend.

c. A satisfactory channel along the right bank in Sawyer Bend would require the reduction of flow through the chute channel and the development of a channel crossing toward the right far enough upstream to provide an adequate channel along the right bank as far as mile 187.7.

d. Complete closure of the entrance to the chute channel with a dike across the entrance with a crest at el 410.0 as in plan A-2 would produce a considerable increase in the width and depth of the channel in Sawyer Bend. However, some modification would be required in the structures riverward of the closure dike to force the crossing toward the right bank farther upstream. This plan would not provide for continuous flow into the chute channel during all river stages which was considered desirable.

e. Vane dikes near the entrance to the chute channel such as in plan B-6 would not be successful in reducing the required amount of flow in the chute channel because of the alignment of currents with respect to the alignment of the dikes and the high head differential across the dikes.

f. A satisfactory channel was developed through Sawyer Bend with plans D-7 and F-4, but these plans would require numerous structures along Mosenthien Island to prevent the channel from moving away from the right bank.

g. A satisfactory channel could be developed with plan H that would require fewer structures along Mosenthien Island than the other plans such as D-7 and F-4. With this plan the dike at mile 188.1 would be subjected to a strong current attack.

h. Plan H-1 was not fully developed in the model but results indicate that a channel somewhat better than that obtained with plan H could be expected because of the elimination of the current attack on the dike near the head of the island and the improvement in alignment and location of the crossing toward the right bank.

i. Most of the shoaling in the entrance to the Chain of Rocks Canal occurs during flows when there is little or no flow over the top of the trail dike. Shoaling during these flows is caused by the sudden expansion of the channel downstream of the trail dike and movement of the slower moving bottom currents to the left. Elimination or reduction of shoaling in the entrance would require the prevention of bottom currents from moving into the

approach by permitting sediment-free surface currents into the approach during low flows similar to those which occur during flows that overtop the trail dike. This can be accomplished to some extent by a gated structure in the trail dike or with a wing dike at the end of the trail dike that would block the bottom currents and permit surface currents to move over the top of the dike.

j. Use of a gated structure in the upper portion of the trail dike as in plan G would be successful in preventing the movement of bed load around the lower end of the trail dike. The gate would have to be of the submergible type and controlled to permit sufficient surface flow to move into the approach area to offset the effect of channel expansion and high enough to prevent sediment from moving over the top of the gate. The amount of flow required and the height of the gate would depend on flow conditions and the amount of deposition near the gate.

k. A low wing dike placed on the end of the trail dike would be successful in preventing most of the bed-load material from moving into the canal approach under the conditions tested. The most successful structure tested was in plan F-4 in which the wing dike was 400 ft long at el 380.0 with a 500-ft extension parallel to the channel on the end of the wing dike at el 367.0.

l. Shoaling in the entrance to the Chain of Rocks Canal will depend on the amount of sediment moving along the trail dike side of the channel in addition to flow conditions. Reduction of flow through the chute channel to the left of Mosenthien Island should tend to decrease the amount of sediment moving toward the trail dike side of the channel and the amount of shoaling in the canal entrance.

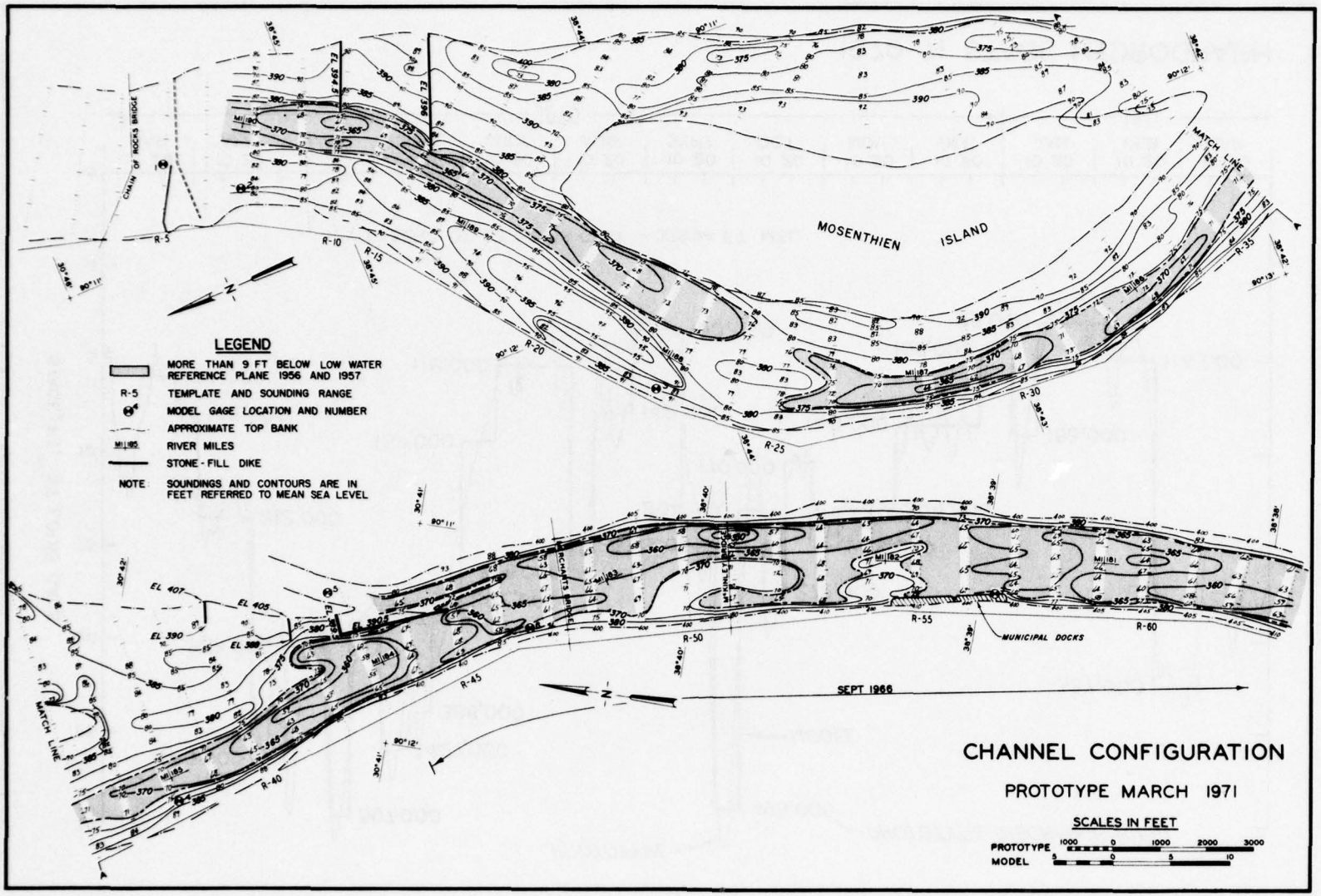
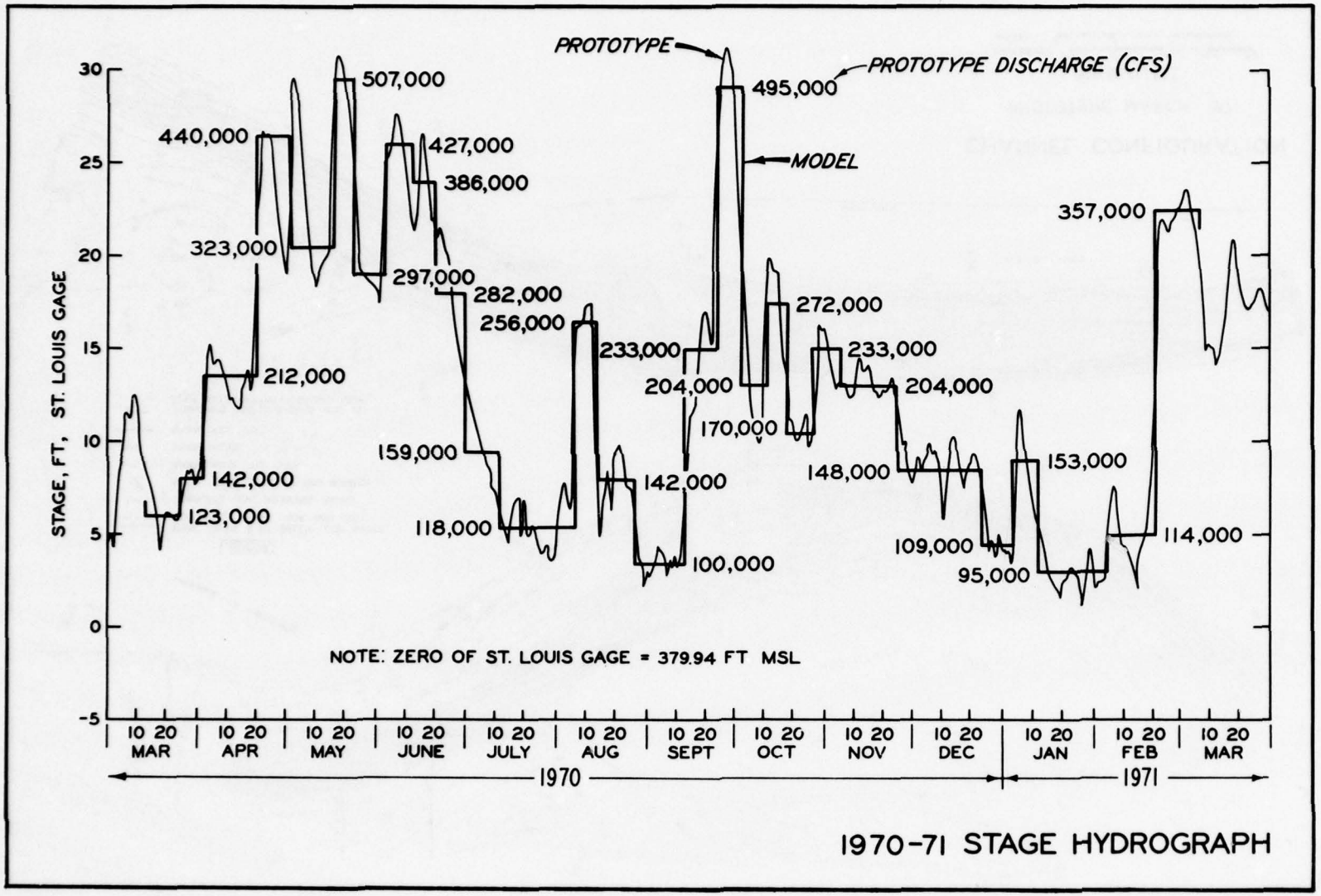

MOSENTHIEN ISLAND
CHAIN OF ROCKS BRIDGE
MATCH LINE
MATCH LINE
R-5
R-10
R-15
R-20
R-25
R-30
R-35
R-40
R-45
R-50
R-55
R-60
MUNICIPAL DOCKS
EL 394.5
EL 398
EL 407
EL 405
EL 390
EL 388
EL 390
MI 195
MI 194
MI 193
MI 192
MI 191
MI 190
MI 189
MI 188
MI 187
MI 186
MI 185
MI 184
MI 183
MI 182
MI 181
SEPT 1966
LEGEND
MORE THAN 9 FT BELOW LOW WATER REFERENCE PLANE 1956 AND 1957
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
APPROXIMATE TOP BANK
RIVER MILES
STONE - FILL DIKE
NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
CHANNEL CONFIGURATION
PROTOTYPE MARCH 1971
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000 3000
MODEL 5 0 5 10

PLATE 1

PLATE 2



1970-71 STAGE HYDROGRAPH

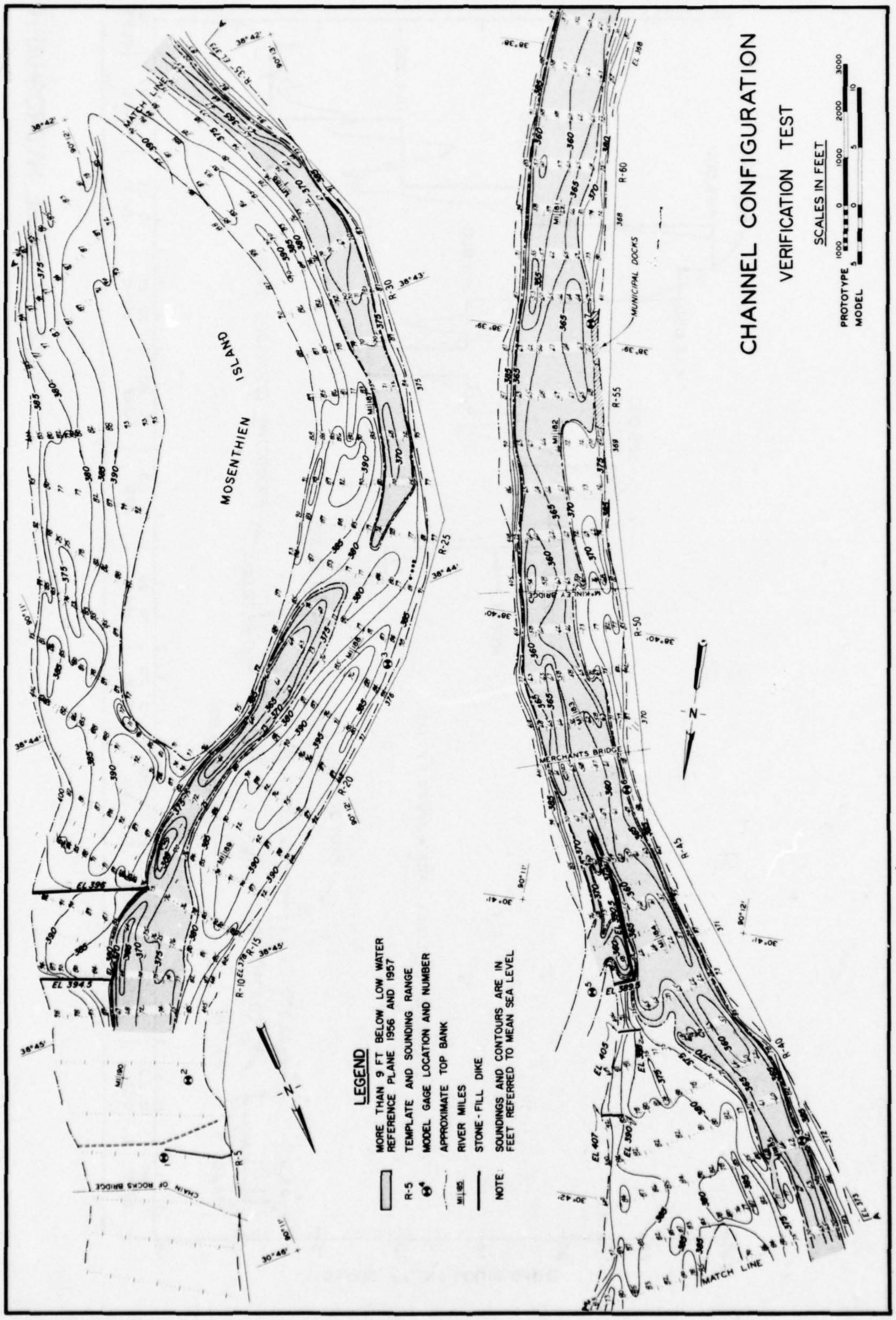
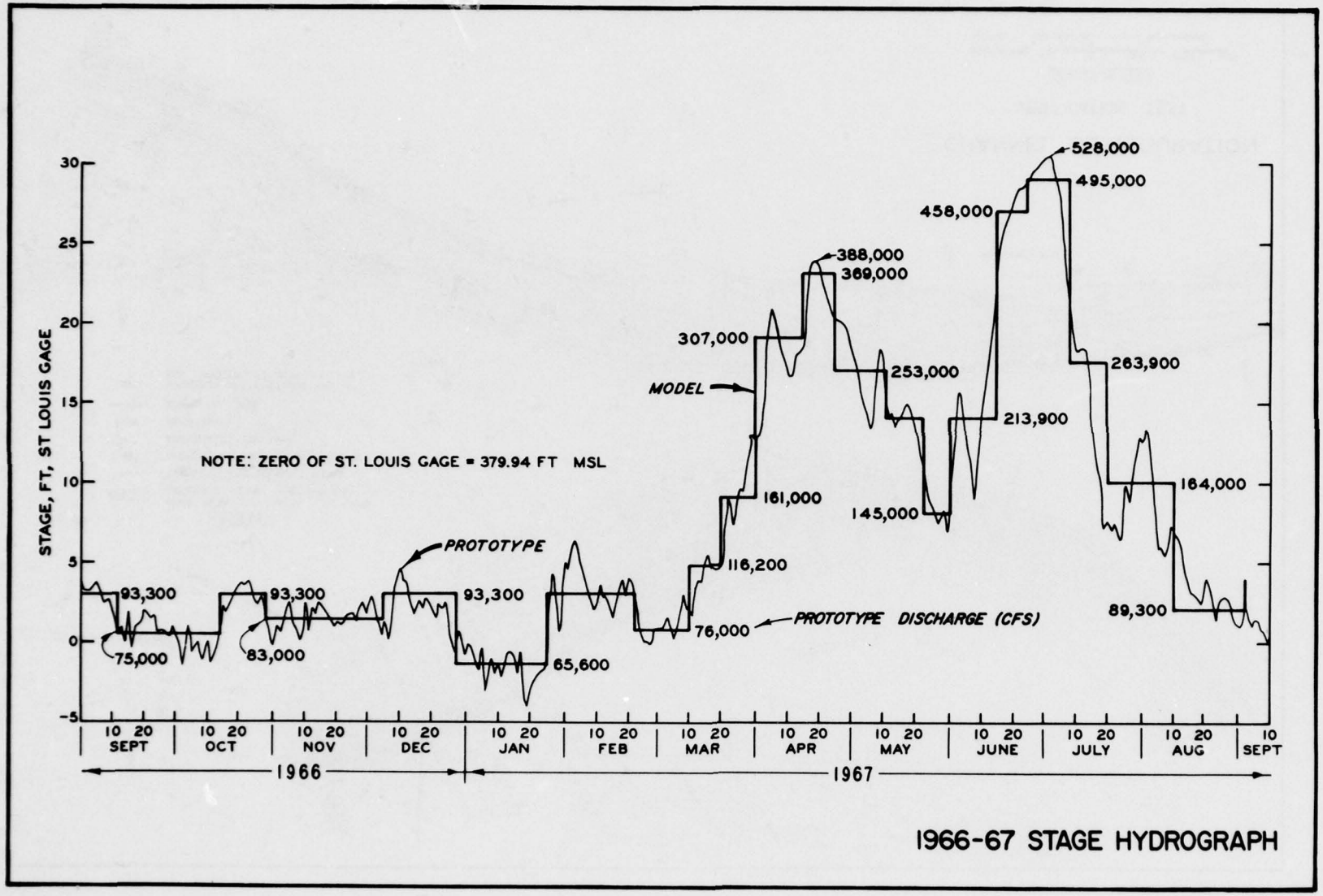
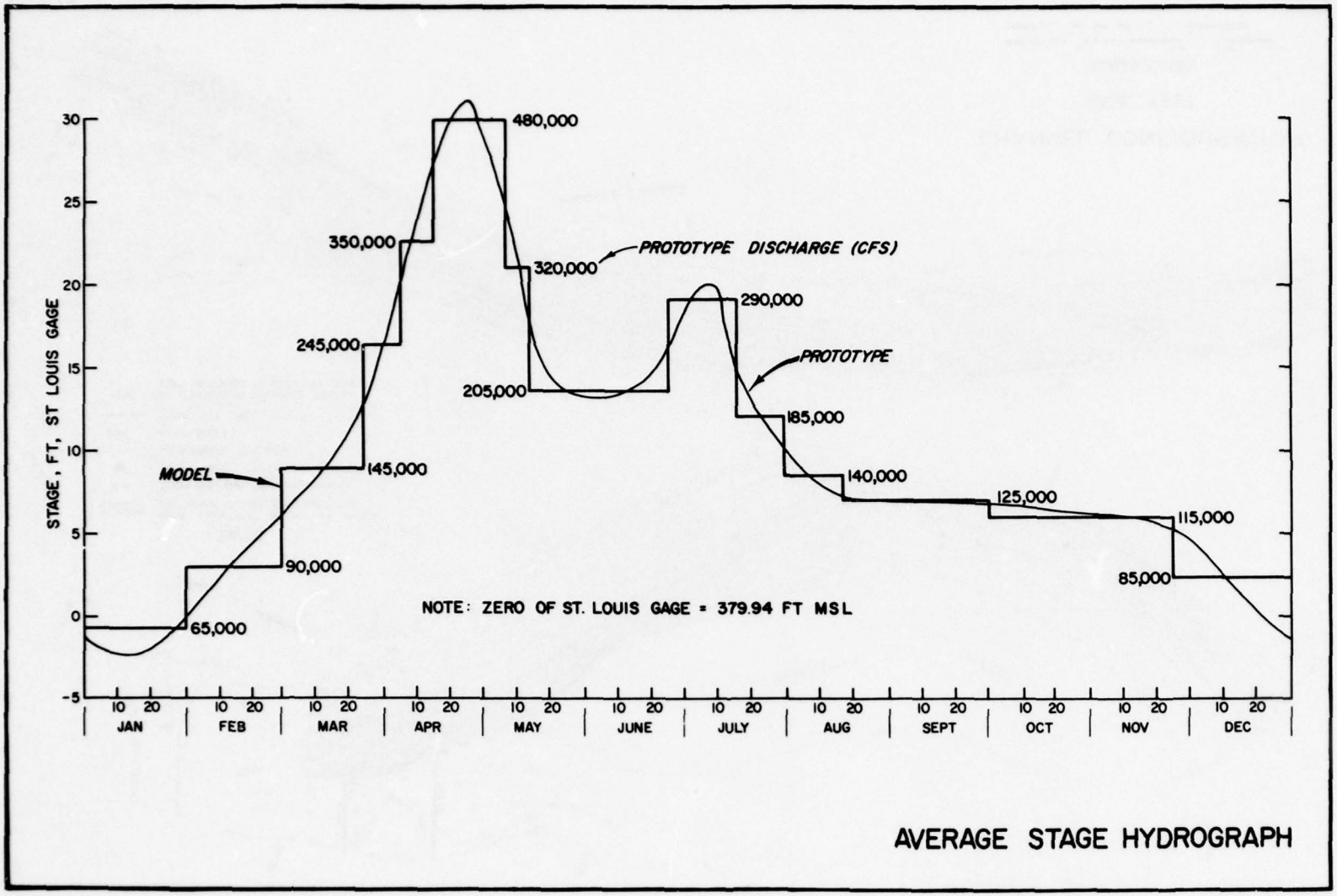

CHANNEL CONFIGURATION
VERIFICATION TEST
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000 3000
MODEL 5 0 5 10
LEGEND
MORE THAN 9 FT BELOW LOW WATER REFERENCE PLANE 1956 AND 1957
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
APPROXIMATE TOP BANK
RIVER MILES
STONE-FILL DIKE
NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
MOSENTHIEN ISLAND
CHAIN OF ROCKS BRIDGE
MERCHANTS BRIDGE
MCKINLEY BRIDGE
MUNICIPAL DOCKS
MATCH LINE
N

PLATE 3

PLATE 4



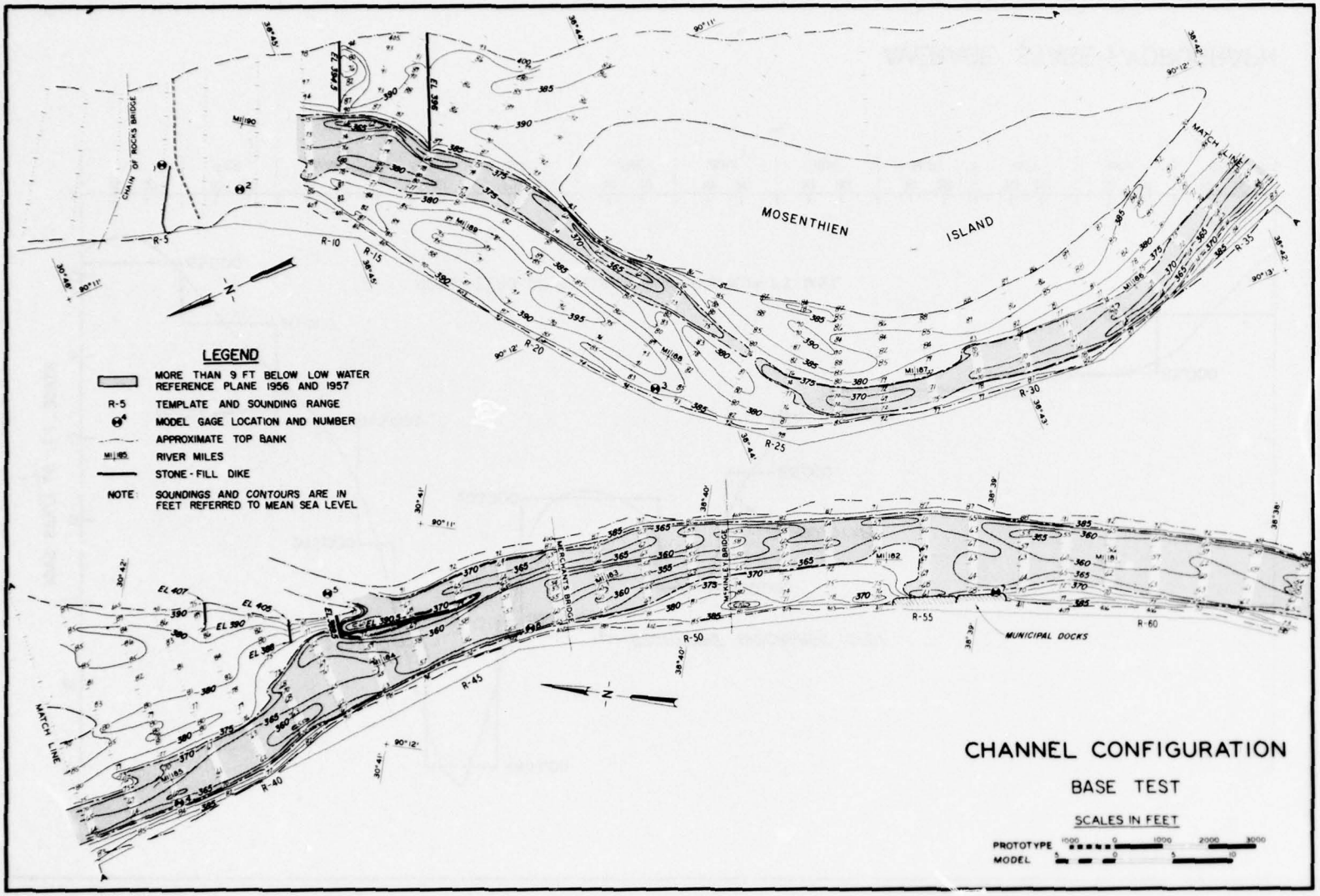
1966-67 STAGE HYDROGRAPH



AVERAGE STAGE HYDROGRAPH

PLATE 5

PLATE 6


LEGEND
MORE THAN 9 FT BELOW LOW WATER REFERENCE PLANE 1956 AND 1957
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
APPROXIMATE TOP BANK
MI 195 RIVER MILES
STONE-FILL DIKE
NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
MOSENTHIEN ISLAND
CHAIN OF ROCKS BRIDGE
MATCH LINE
MERCHANTS BRIDGE
McKINLEY BRIDGE
MUNICIPAL DOCKS
R-5
R-10
R-15
R-20
R-25
R-30
R-35
R-40
R-45
R-50
R-55
R-60
EL 407
EL 405
EL 390
EL 388
EL 396
EL 394
CHANNEL CONFIGURATION
BASE TEST
SCALES IN FEET
PROTOTYPE
MODEL

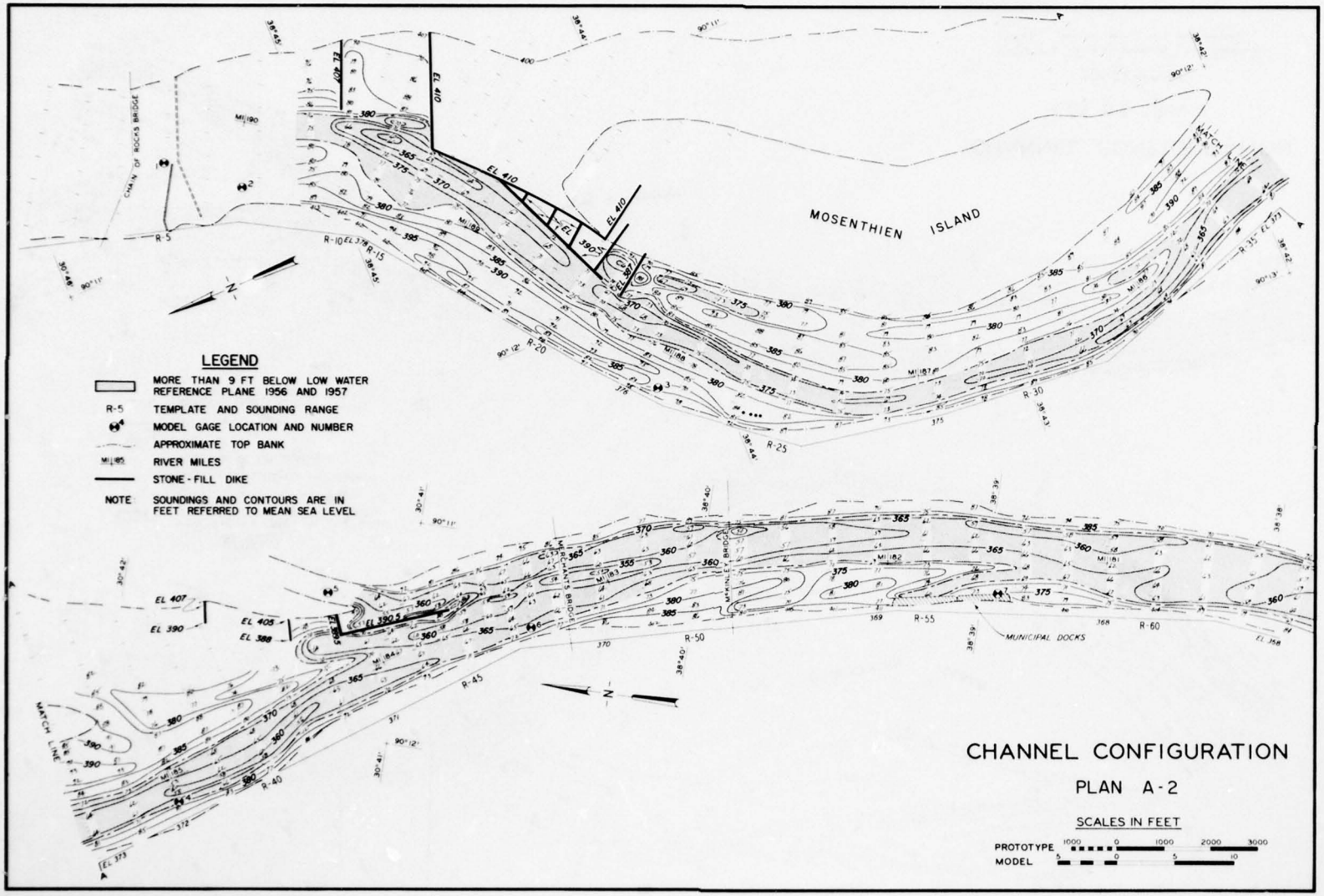
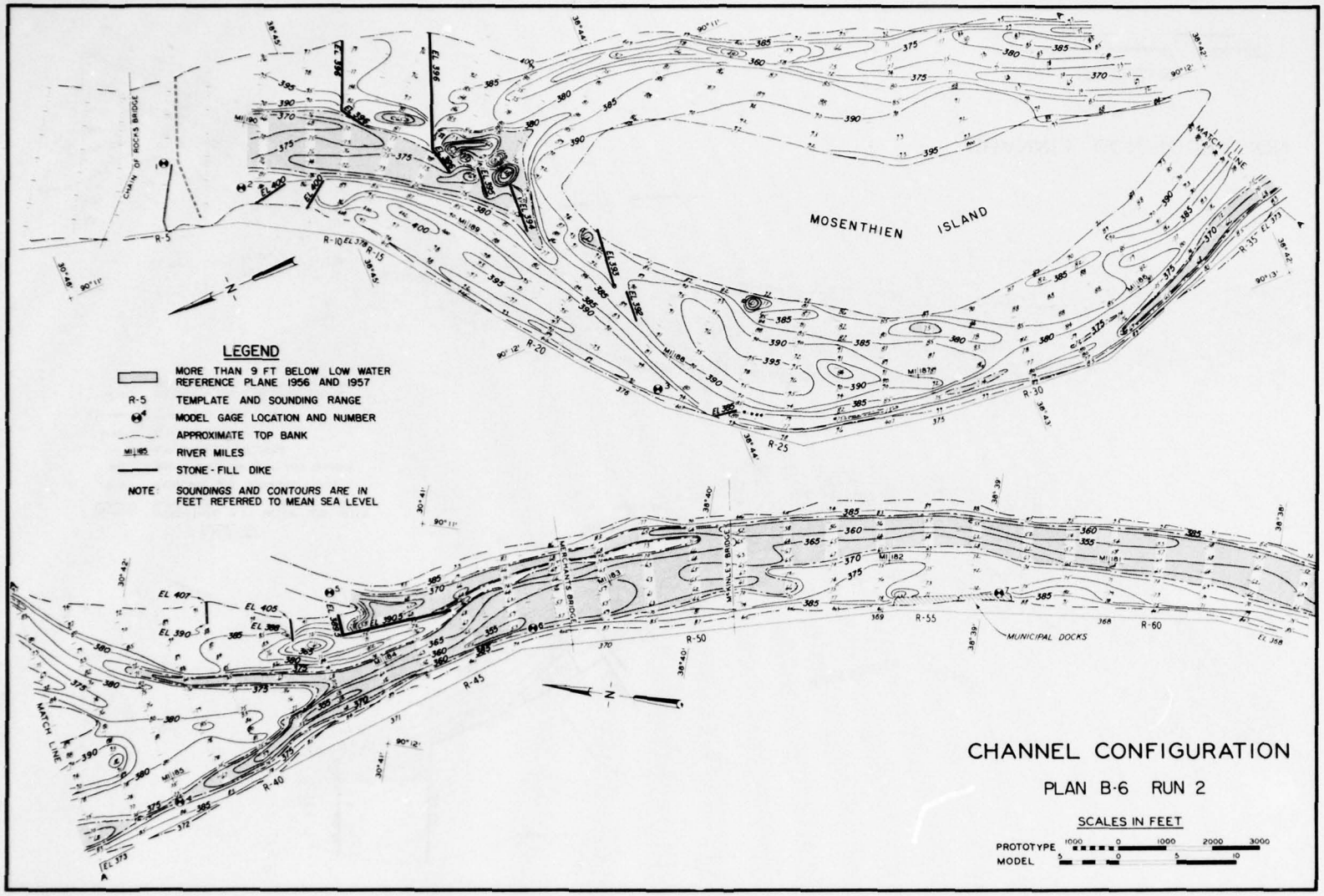

MOSENTHIEN ISLAND
CHAIN OF ROCKS BRIDGE
MATCH LINE
MCKINLEY BRIDGE
MERCHANTS BRIDGE
MUNICIPAL DOCKS
EL 410
EL 407
EL 390
EL 405
EL 388
EL 390.5
EL 373
LEGEND
MORE THAN 9 FT BELOW LOW WATER REFERENCE PLANE 1956 AND 1957
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
APPROXIMATE TOP BANK
MI 185 RIVER MILES
STONE-FILL DIKE
NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
CHANNEL CONFIGURATION
PLAN A-2
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000 3000
MODEL 5 0 5 10

PLATE 7

PLATE 8


MOSENTHIEN ISLAND
CHAIN OF ROCKS BRIDGE
MERCHANTS BRIDGE
McKINLEY BRIDGE
MUNICIPAL DOCKS
MATCH LINE
LEGEND
MORE THAN 9 FT BELOW LOW WATER REFERENCE PLANE 1956 AND 1957
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
APPROXIMATE TOP BANK
MI 195 RIVER MILES
STONE-FILL DIKE
NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
CHANNEL CONFIGURATION
PLAN B-6 RUN 2
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000 3000
MODEL 5 0 5 10

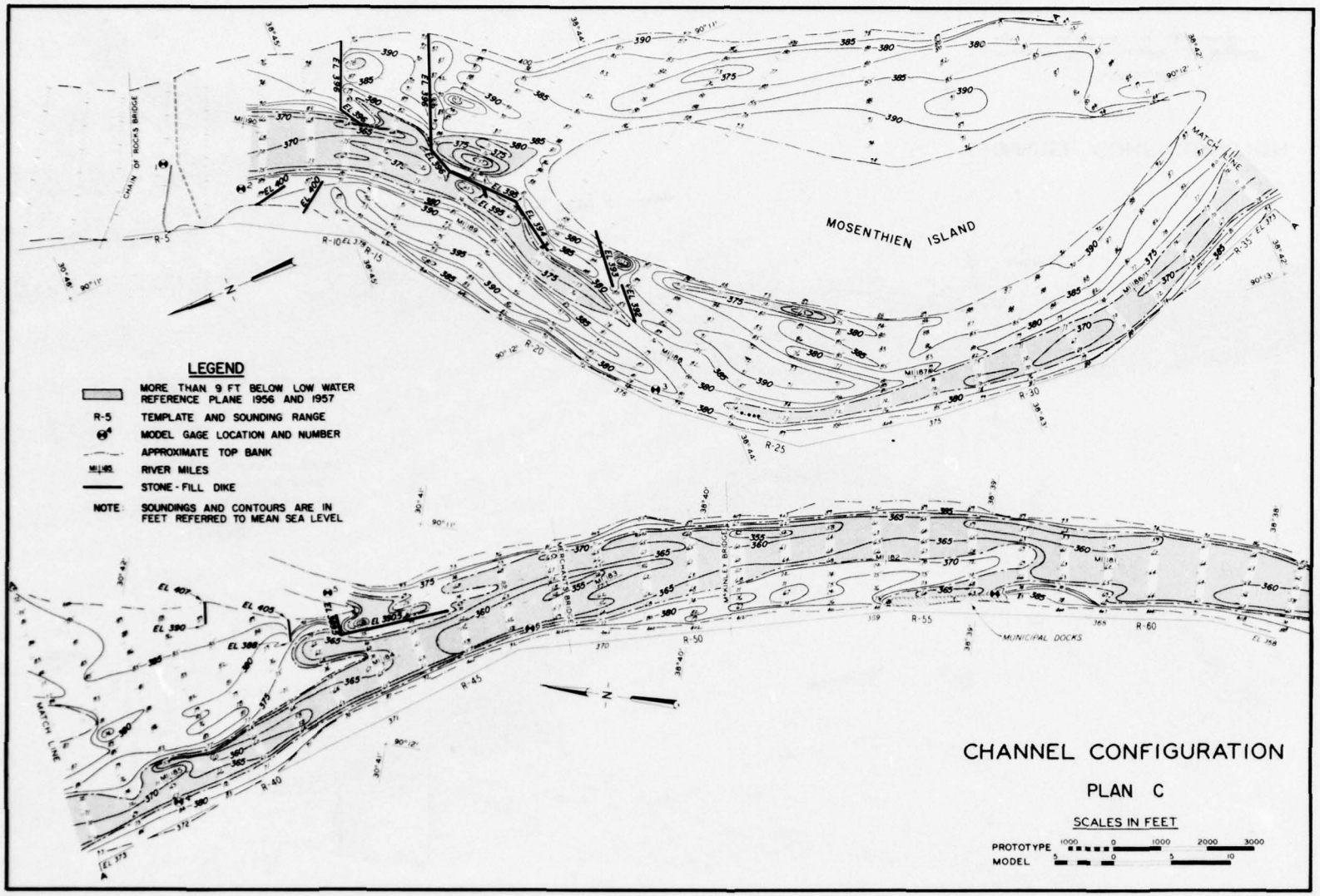
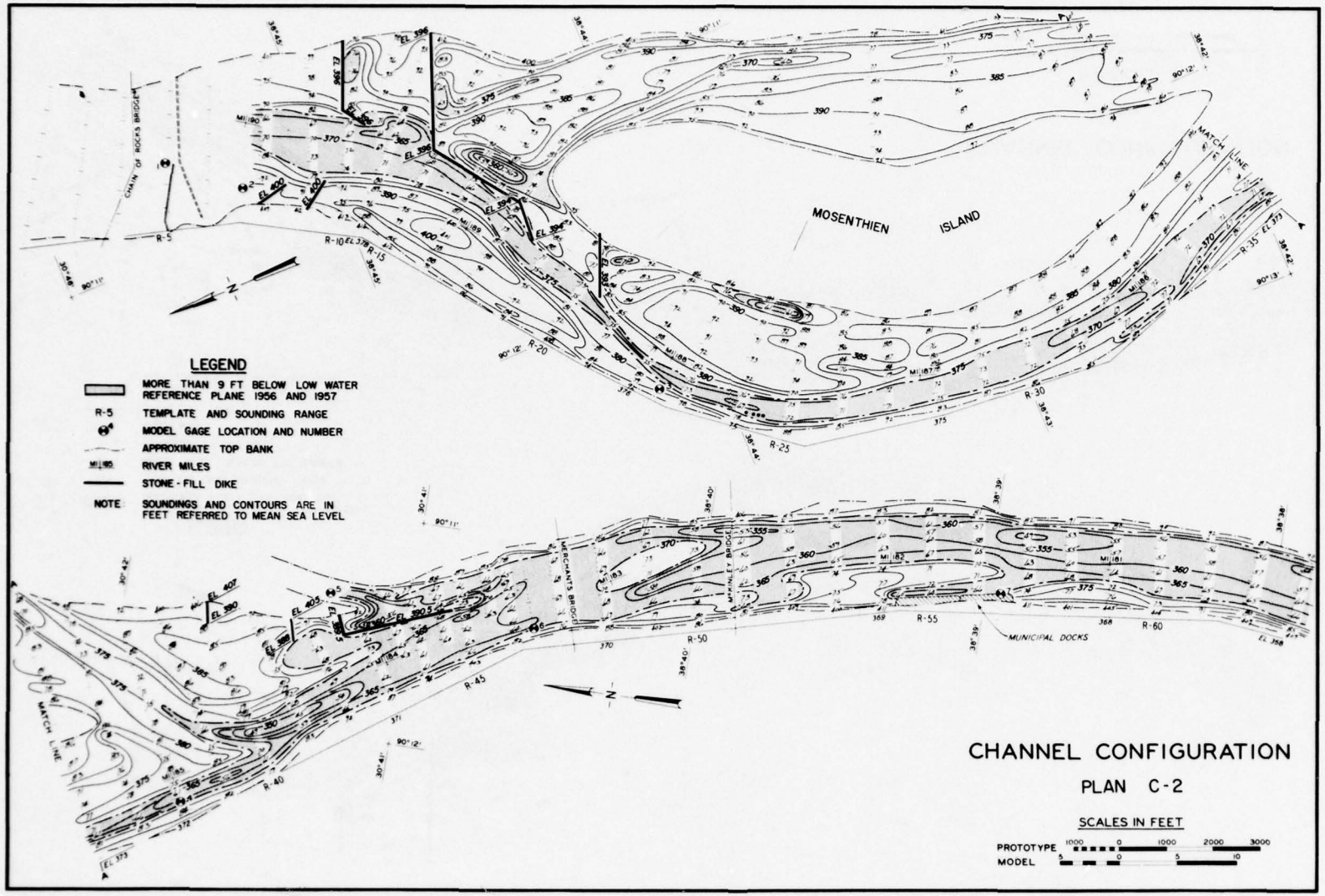

LEGEND
MORE THAN 9 FT BELOW LOW WATER REFERENCE PLANE 1956 AND 1957
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
APPROXIMATE TOP BANK
MI 185 RIVER MILES
STONE - FILL DIKE
NOTE: SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
MOSENTHIEN ISLAND
CHAIN OF ROCKS BRIDGE
MATCH LINE
MUNICIPAL DOCKS
MCKINLEY BRIDGE
CHANNEL CONFIGURATION
PLAN C
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000 3000
MODEL 5 0 5 10

PLATE 9

PLATE 10



CHANNEL CONFIGURATION

PLAN C-2

SCALES IN FEET

PROTOTYPE 1000 0 1000 2000 3000

MODEL 5 0 5 10

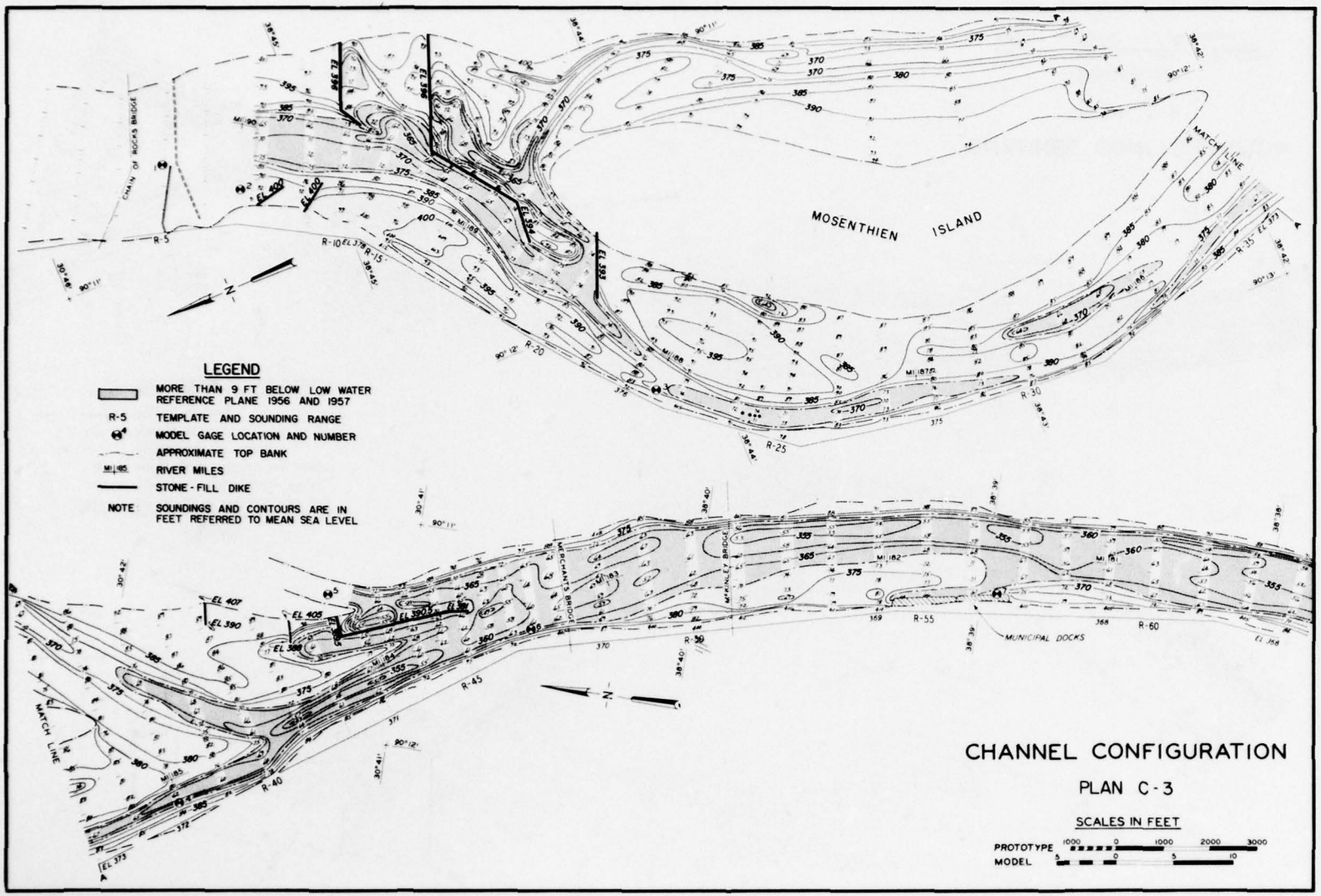
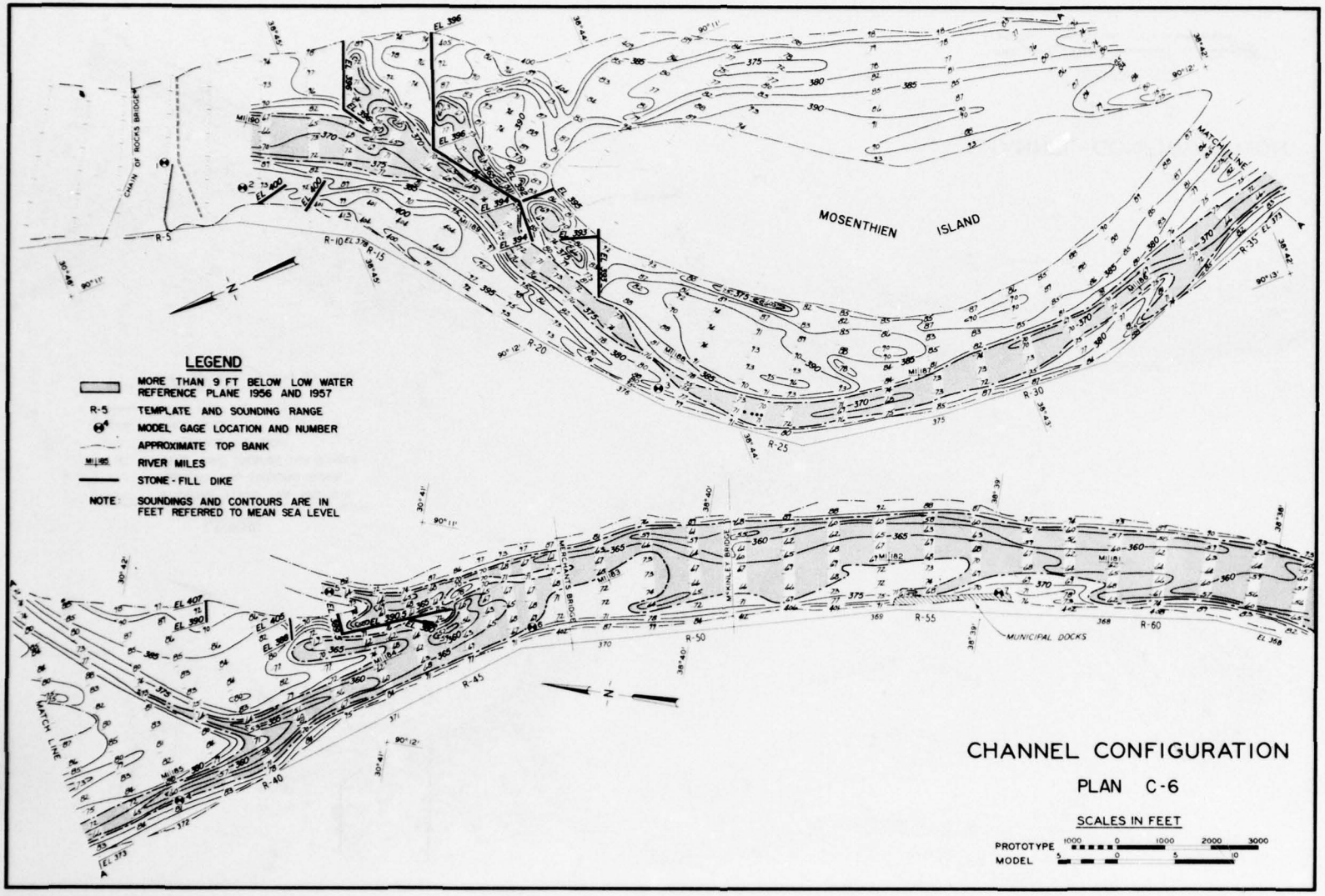

LEGEND
MORE THAN 9 FT BELOW LOW WATER REFERENCE PLANE 1956 AND 1957
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
APPROXIMATE TOP BANK
MI 185 RIVER MILES
STONE - FILL DIKE
NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
MOSENTHIEN ISLAND
CHAIN OF ROCKS BRIDGE
MATCH LINE
MERCHANTS BRIDGE
McKINLEY BRIDGE
MUNICIPAL DOCKS
CHANNEL CONFIGURATION
PLAN C-3
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000 3000
MODEL 5 0 5 10

PLATE 11

PLATE 12


MOSENTHIEN ISLAND
CHAIN OF ROCKS BRIDGE
MATCH LINE
MERCHANTS BRIDGE
McKINLEY BRIDGE
MUNICIPAL DOCKS
LEGEND
MORE THAN 9 FT BELOW LOW WATER REFERENCE PLANE 1956 AND 1957
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
APPROXIMATE TOP BANK
MI 185 RIVER MILES
STONE - FILL DIKE
NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
CHANNEL CONFIGURATION
PLAN C-6
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000 3000
MODEL 5 0 5 10

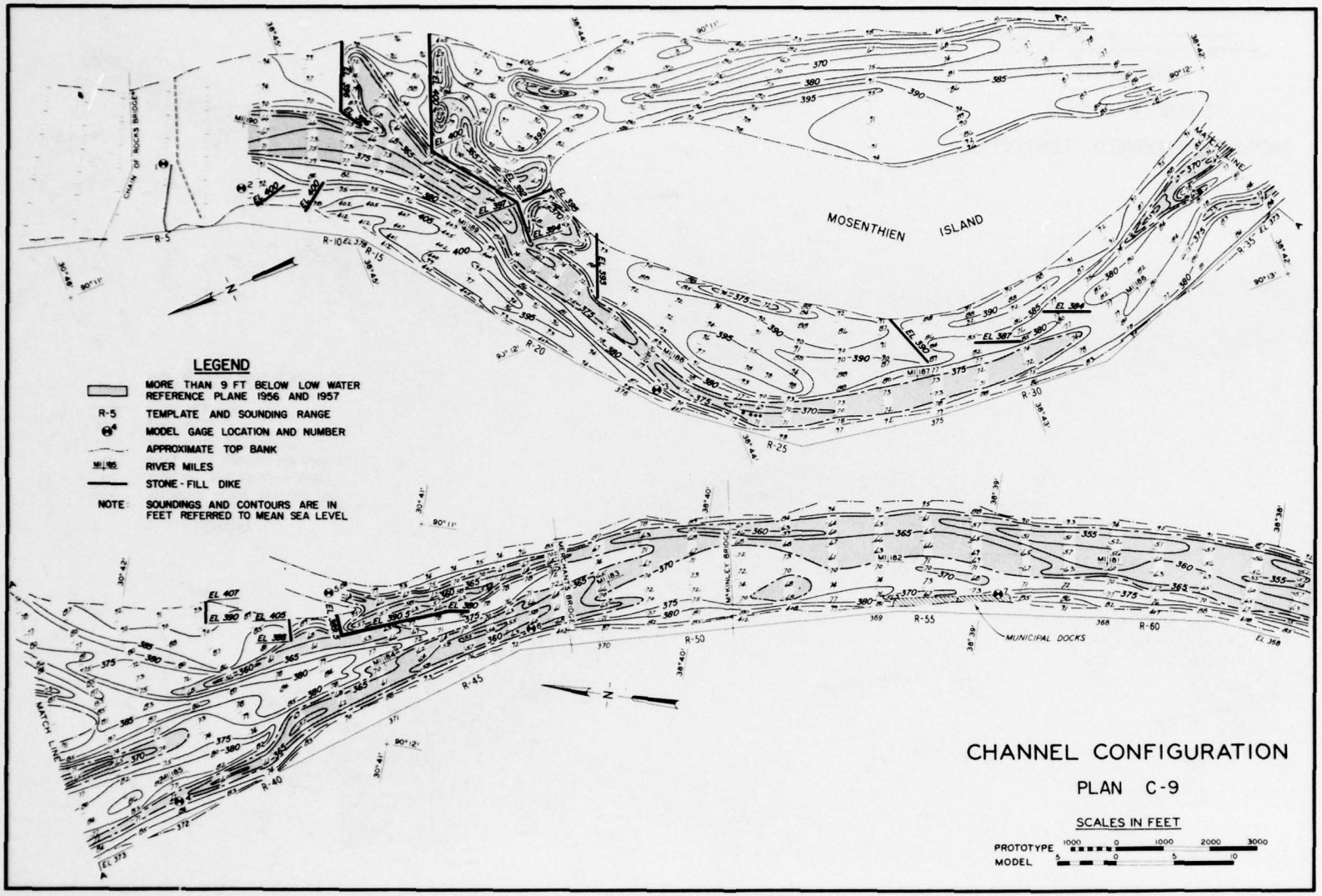
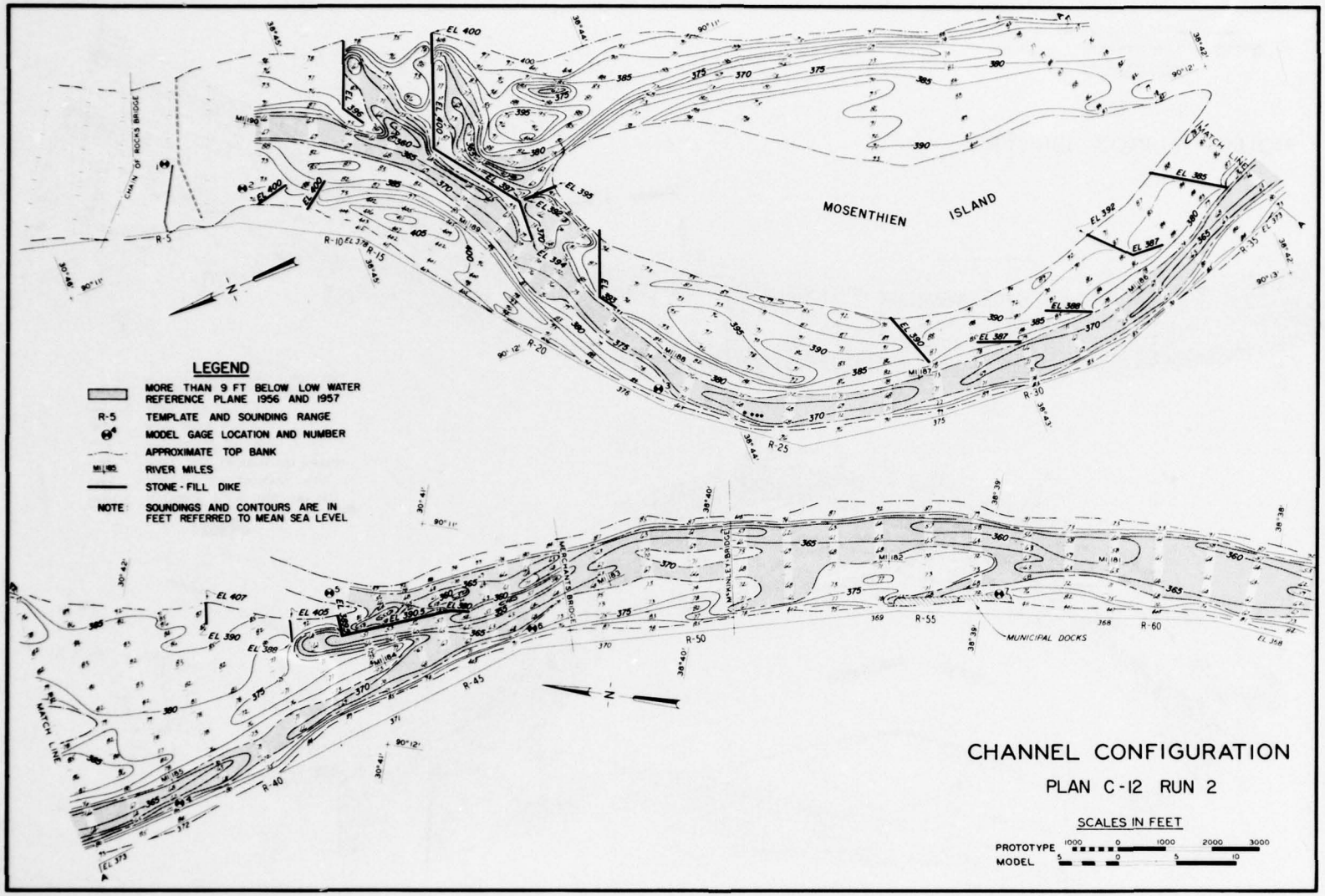

MOSENTHIEN ISLAND
CHAIN OF ROCKS BRIDGE
MATCH LINE
MCKINLEY BRIDGE
MUNICIPAL DOCKS
LEGEND
MORE THAN 9 FT BELOW LOW WATER REFERENCE PLANE 1956 AND 1957
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
APPROXIMATE TOP BANK
MI 185 RIVER MILES
STONE - FILL DIKE
NOTE: SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
CHANNEL CONFIGURATION
PLAN C-9
SCALES IN FEET
PROTOTYPE
MODEL

PLATE 13

PLATE 14


MOSENTHIEN ISLAND
CHAN. OF ROCKS BRIDGE
MERCHANTS BRIDGE
MUNICIPAL DOCKS
MATCH LINE
LEGEND
MORE THAN 9 FT BELOW LOW WATER REFERENCE PLANE 1956 AND 1957
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
APPROXIMATE TOP BANK
MI 185 RIVER MILES
STONE - FILL DIKE
NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
CHANNEL CONFIGURATION
PLAN C-12 RUN 2
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000 3000
MODEL 5 0 5 10

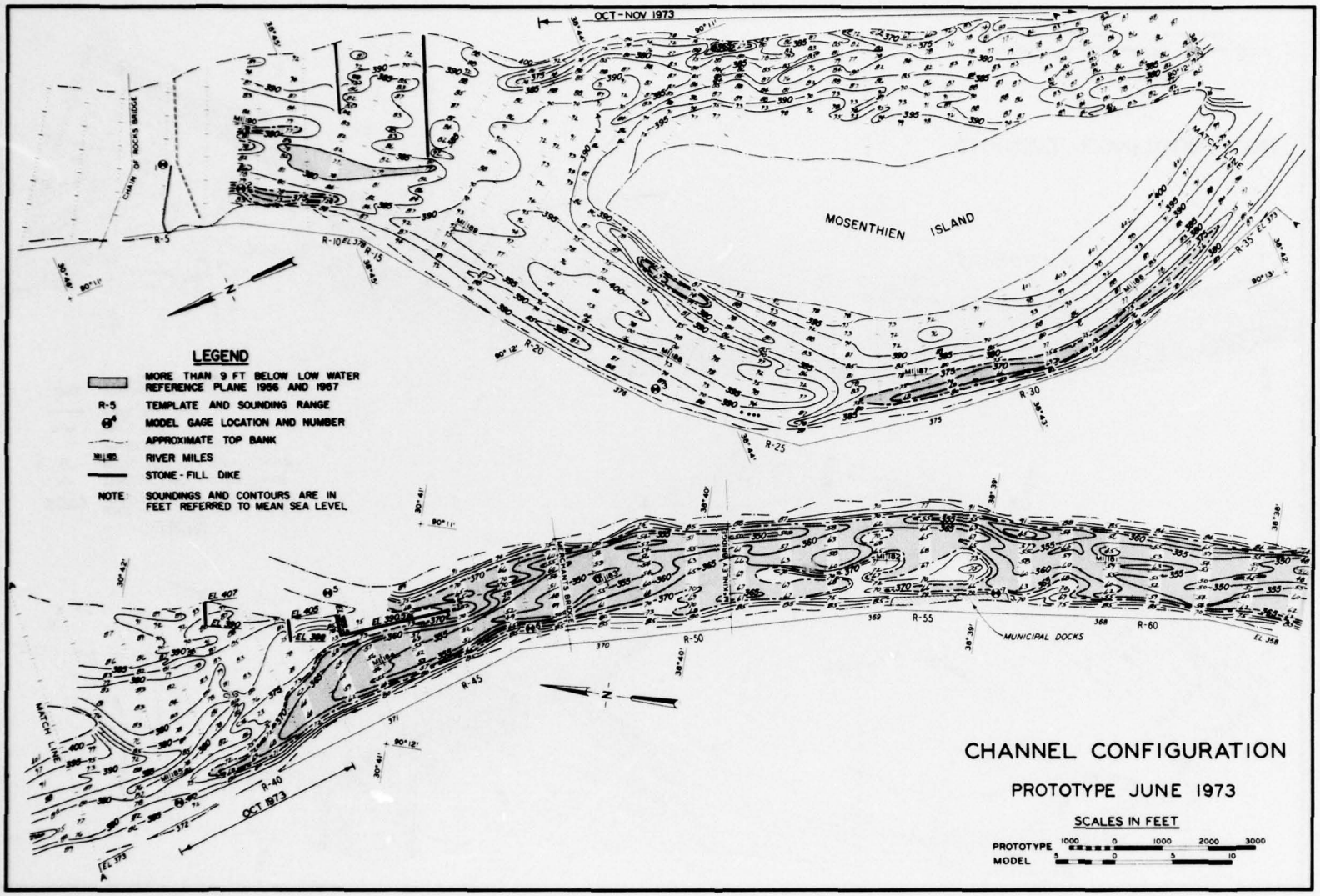
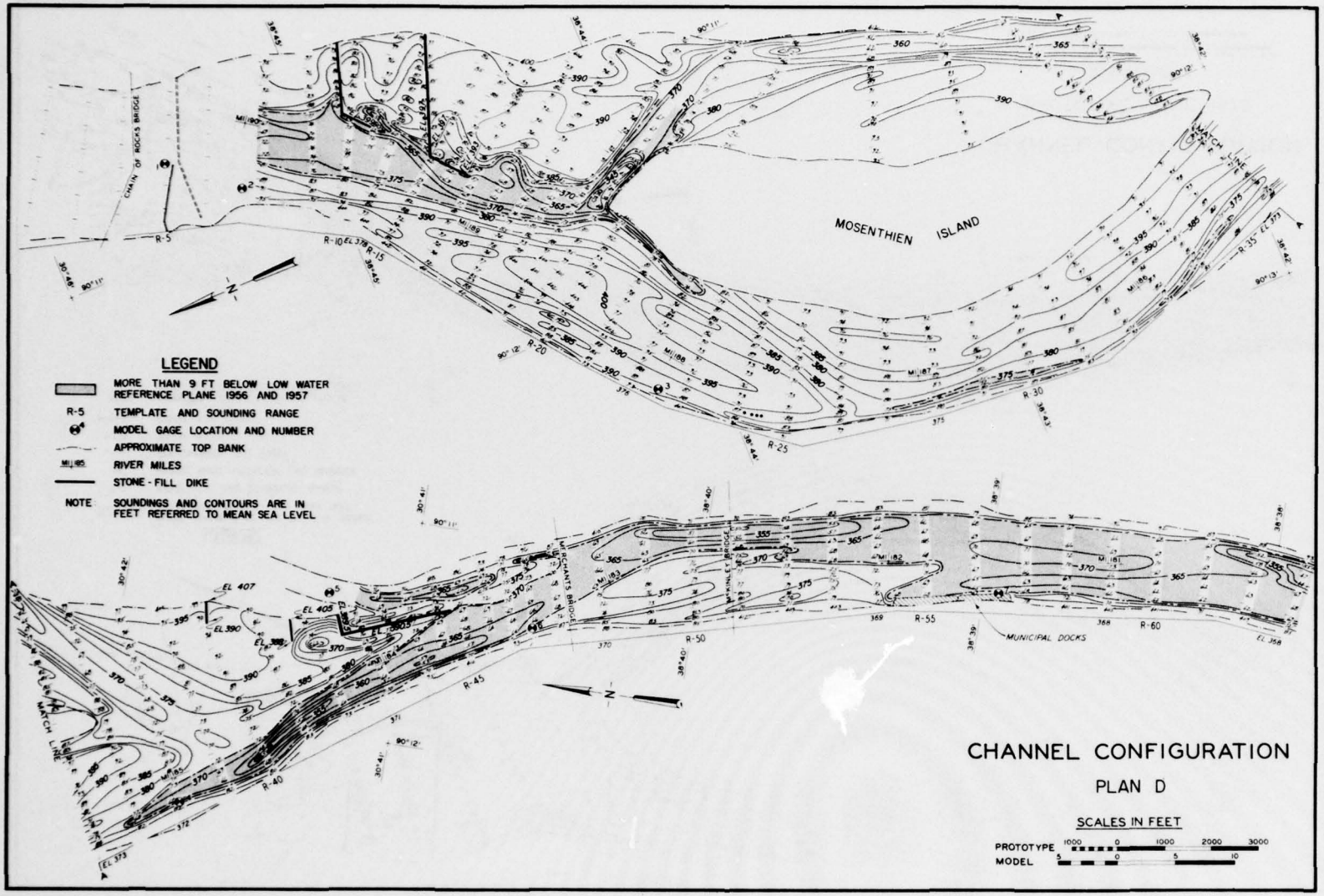

OCT-NOV 1973
MOSENTHIEN ISLAND
CHAIN OF ROCKS BRIDGE
MATCH LINE
R-5
R-10
R-15
R-20
R-25
R-30
R-35
R-40
R-45
R-50
R-55
R-60
MERCHANTS BRIDGE
McKINLEY BRIDGE
MUNICIPAL DOCKS
OCT 1973
LEGEND
MORE THAN 9 FT BELOW LOW WATER REFERENCE PLANE 1956 AND 1967
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
APPROXIMATE TOP BANK
RIVER MILES
STONE-FILL DIKE
NOTE: SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
CHANNEL CONFIGURATION
PROTOTYPE JUNE 1973
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000 3000
MODEL 5 0 5 10

PLATE 15

PLATE 16


MOSENTHIEN ISLAND
CHAIN OF ROCKS BRIDGE
MERCHANTS BRIDGE
MacARTHUR BRIDGE
MUNICIPAL DOCKS
MATCH LINE
LEGEND
MORE THAN 9 FT BELOW LOW WATER REFERENCE PLANE 1956 AND 1957
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
APPROXIMATE TOP BANK
MI 185 RIVER MILES
STONE - FILL DIKE
NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
CHANNEL CONFIGURATION
PLAN D
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000 3000
MODEL 5 0 5 10

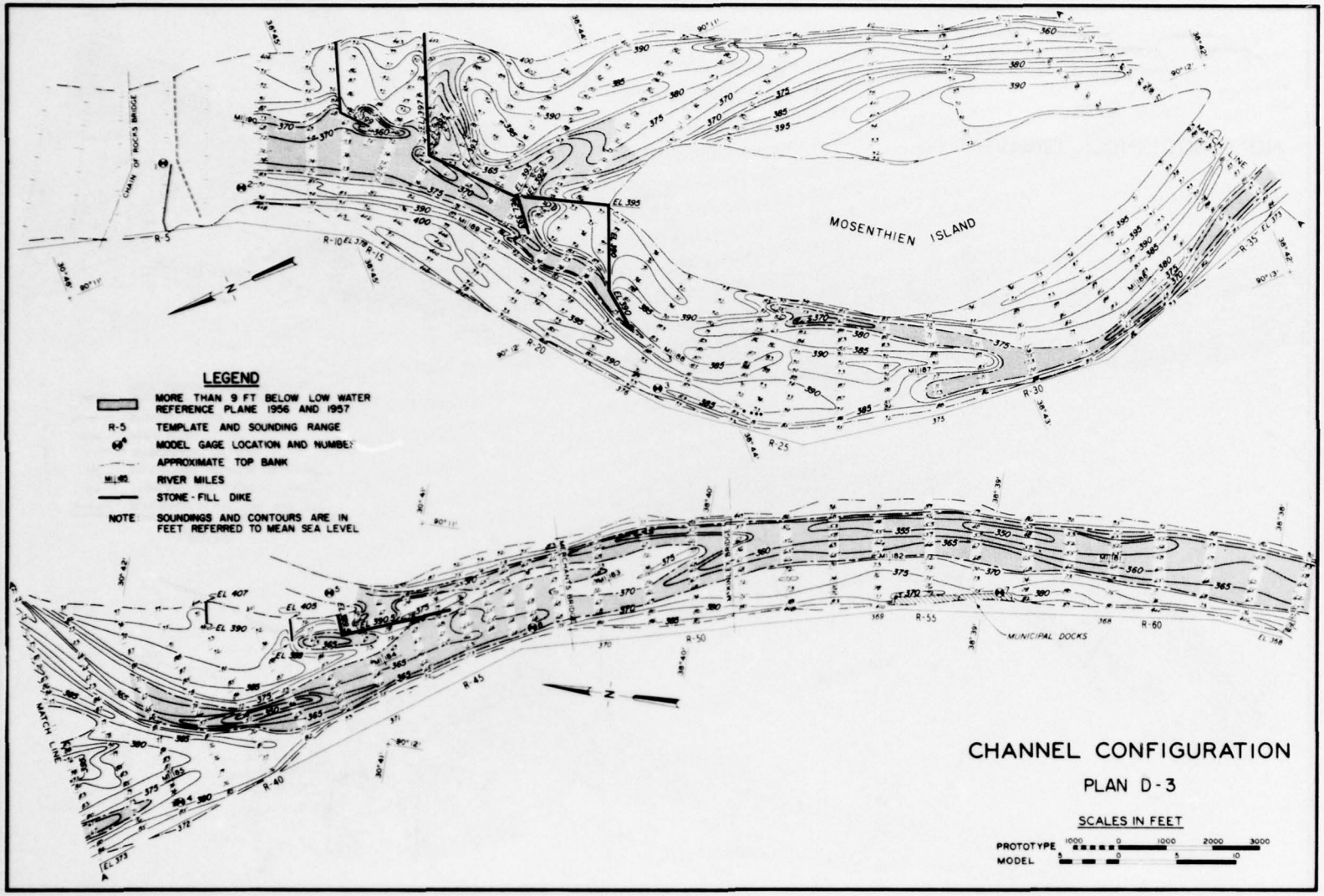
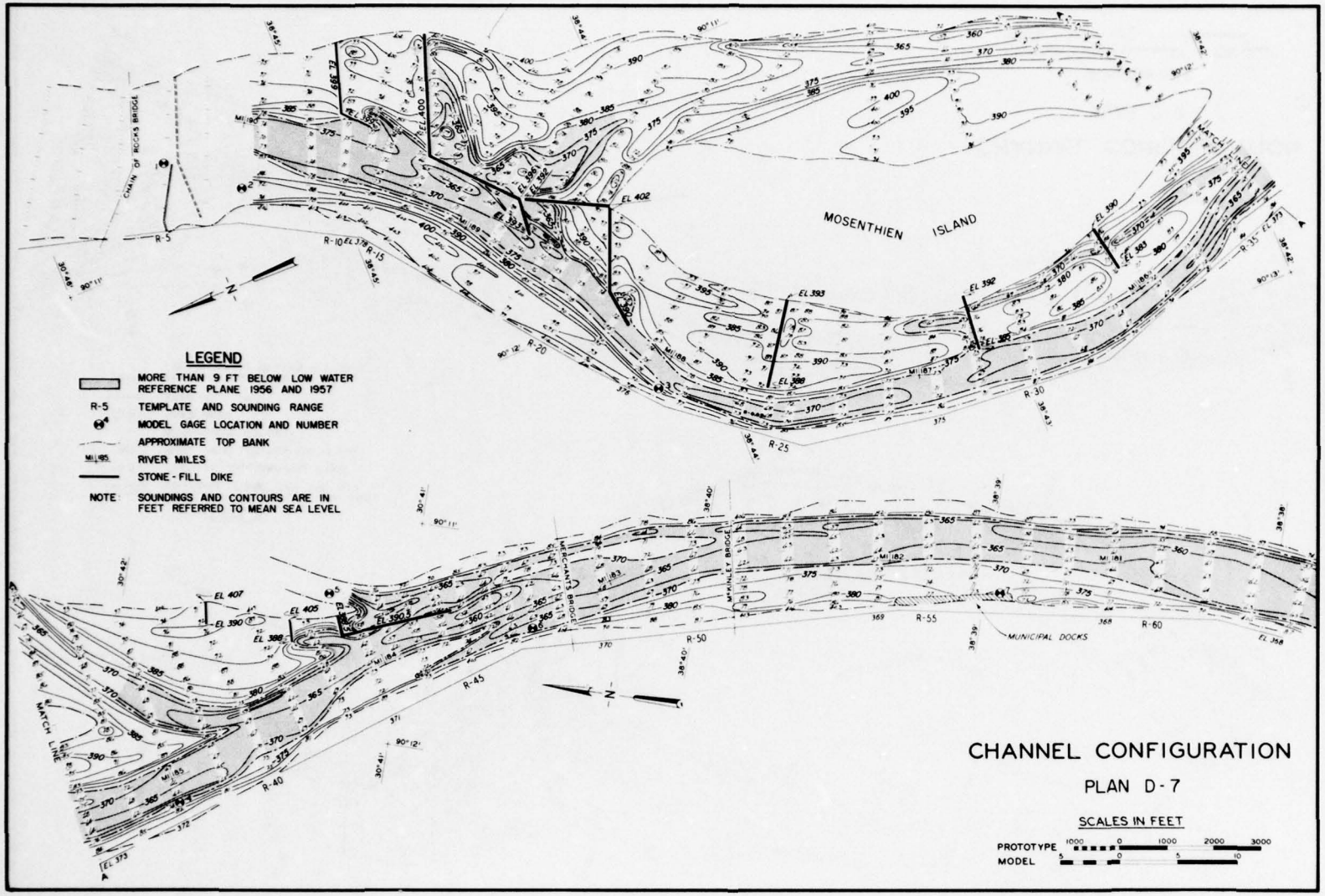

LEGEND
MORE THAN 9 FT BELOW LOW WATER REFERENCE PLANE 1956 AND 1957
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
APPROXIMATE TOP BANK
MI 190 RIVER MILES
STONE - FILL DIKE
NOTE: SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
MOSENTHIEN ISLAND
CHAIN OF ROCKS BRIDGE
MATCH LINE
MUNICIPAL DOCKS
N
CHANNEL CONFIGURATION
PLAN D-3
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000 3000
MODEL 5 0 5 10

PLATE 17

PLATE 18


MOSENTHIEN ISLAND
CHAIN OF ROCKS BRIDGE
MERCHANTS BRIDGE
MacARTHUR BRIDGE
MUNICIPAL DOCKS
MATCH LINE
LEGEND
MORE THAN 9 FT BELOW LOW WATER REFERENCE PLANE 1956 AND 1957
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
APPROXIMATE TOP BANK
MI 195 RIVER MILES
STONE-FILL DIKE
NOTE: SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
CHANNEL CONFIGURATION
PLAN D-7
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000 3000
MODEL 5 0 5 10

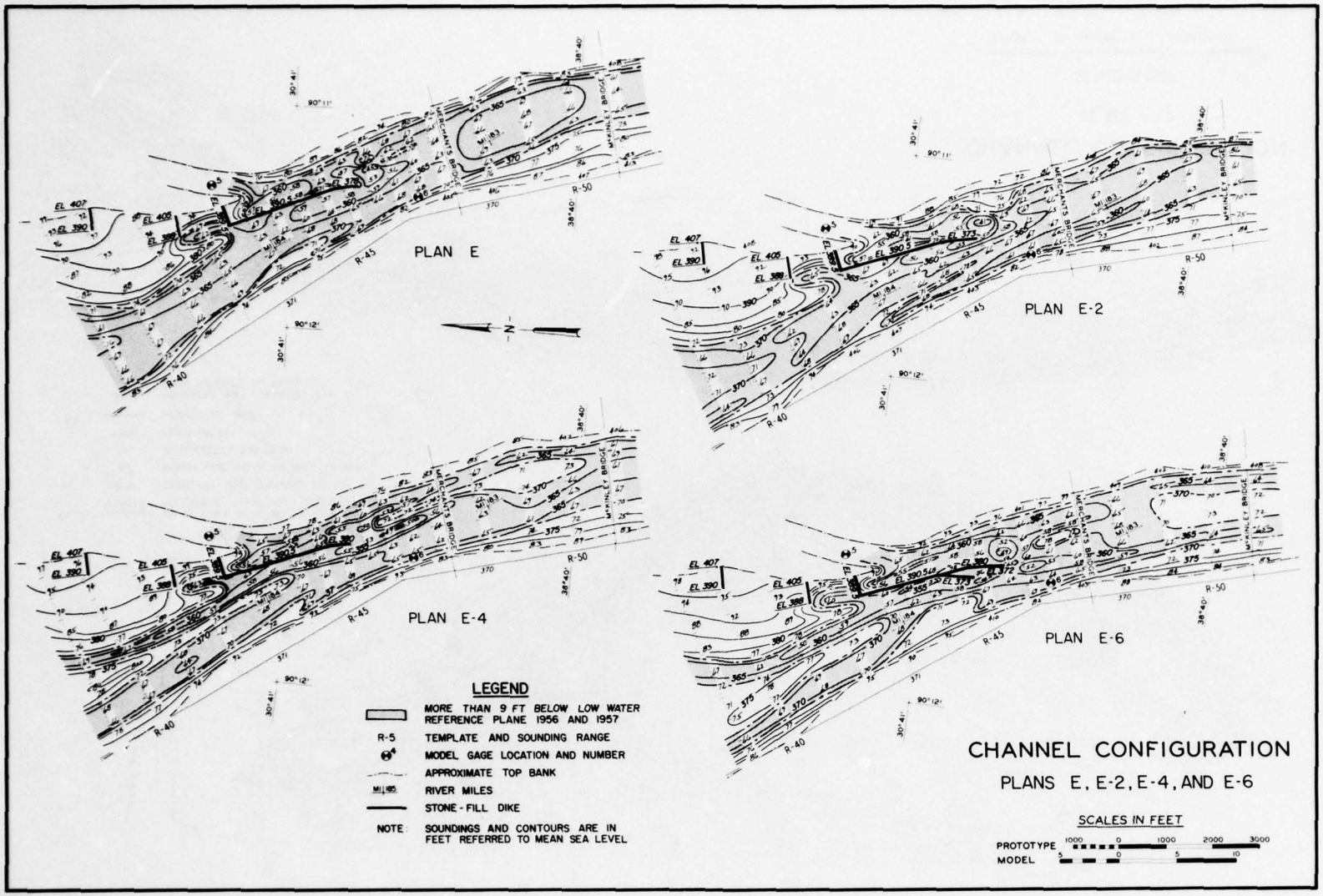
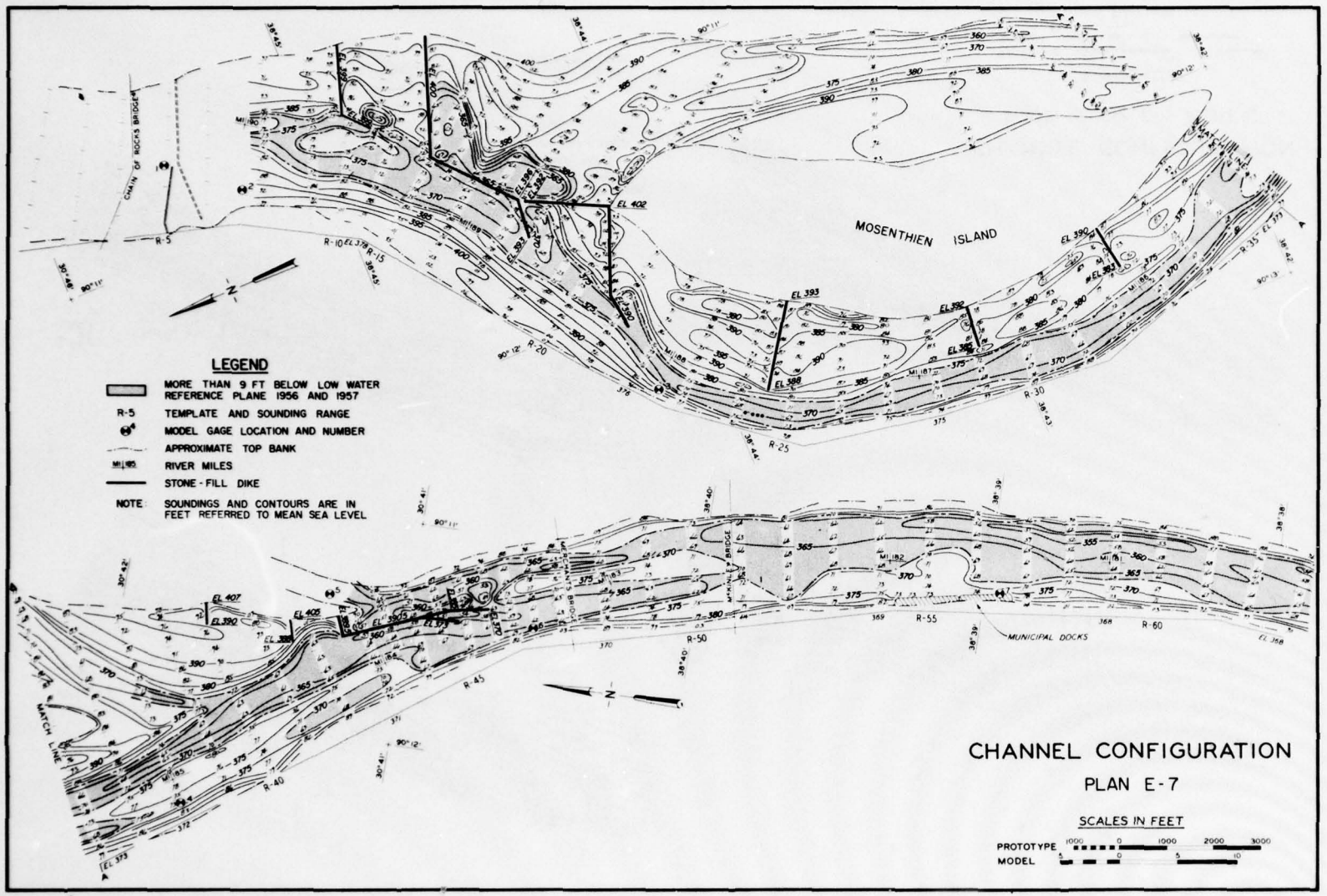

PLAN E
PLAN E-2
PLAN E-4
PLAN E-6
LEGEND
MORE THAN 9 FT BELOW LOW WATER REFERENCE PLANE 1956 AND 1957
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
APPROXIMATE TOP BANK
MI 185 RIVER MILES
STONE - FILL DIKE
NOTE: SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
CHANNEL CONFIGURATION
PLANS E, E-2, E-4, AND E-6
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000 3000
MODEL 5 0 5 10

PLATE 19

PLATE 20


LEGEND
MORE THAN 9 FT BELOW LOW WATER REFERENCE PLANE 1956 AND 1957
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
APPROXIMATE TOP BANK
MI 195 RIVER MILES
STONE - FILL DIKE
NOTE: SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
MOSENTHIEN ISLAND
CHAIN OF ROCKS BRIDGE
MUNICIPAL DOCKS
MATCH LINE
CHANNEL CONFIGURATION
PLAN E-7
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000 3000
MODEL 0 5 10

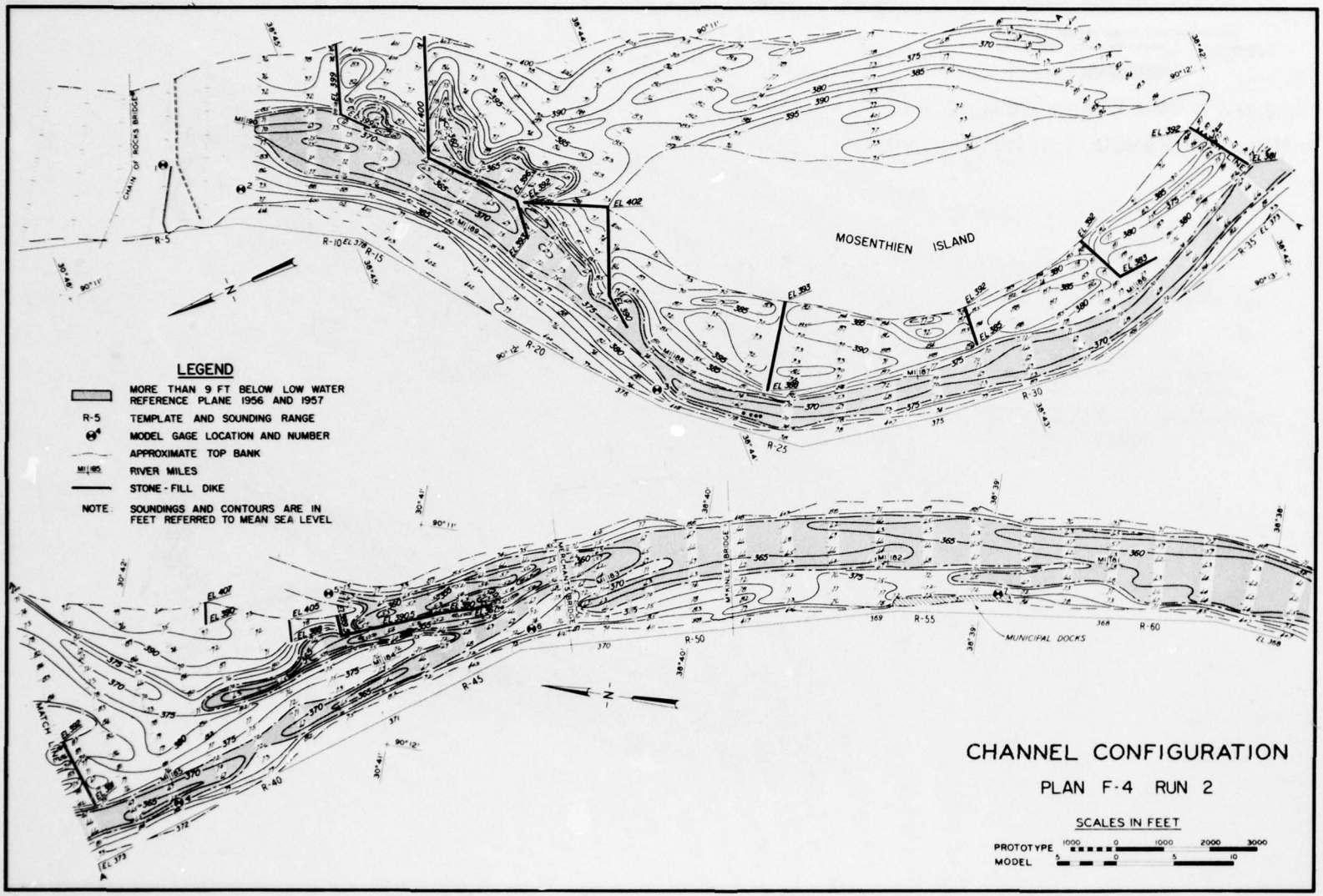
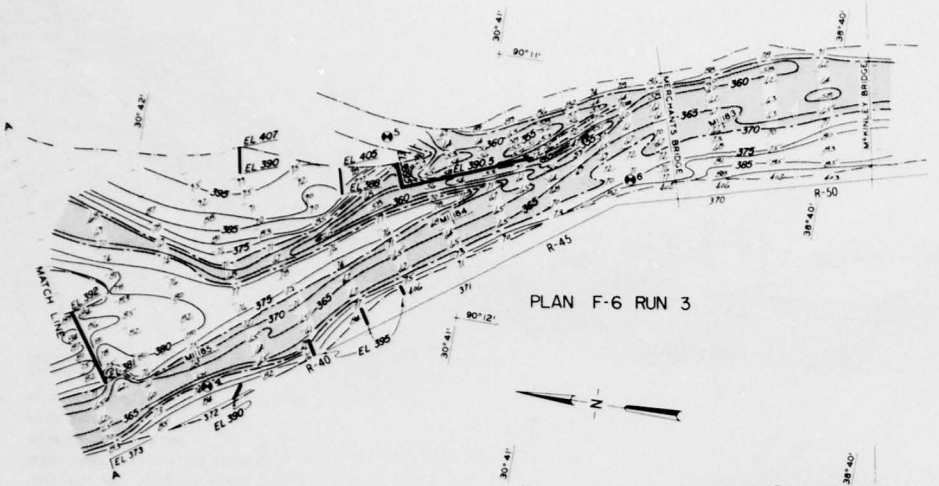
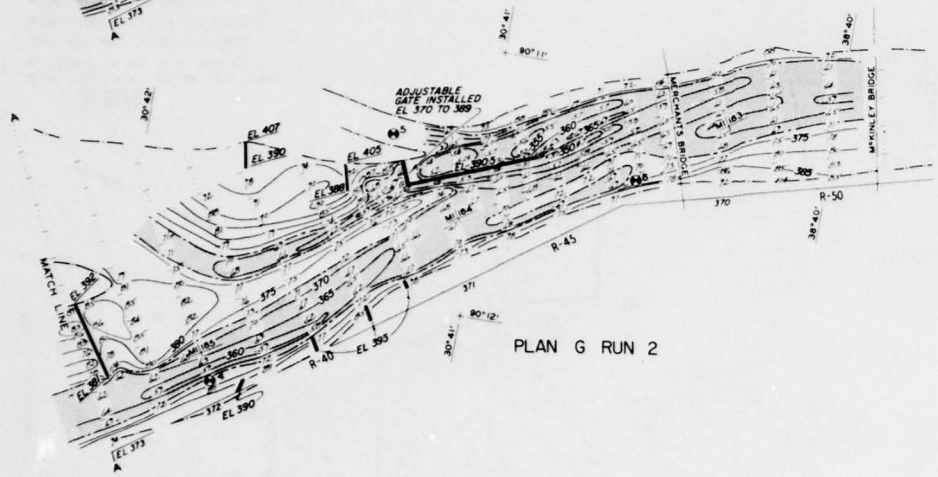

MOSENTHIEN ISLAND
CHAIN OF ROCKS BRIDGE
MATCH LINE
MUNICIPAL DOCKS
LEGEND
MORE THAN 9 FT BELOW LOW WATER REFERENCE PLANE 1956 AND 1957
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
APPROXIMATE TOP BANK
MI 195 RIVER MILES
STONE - FILL DIKE
NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
CHANNEL CONFIGURATION
PLAN F-4 RUN 2
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000 3000
MODEL 5 0 5 10

PLATE 21

PLATE 22





LEGEND

	MORE THAN 9 FT BELOW LOW WATER REFERENCE PLANE 1956 AND 1957
R-5	TEMPLATE AND SOUNDING RANGE
64	MODEL GAGE LOCATION AND NUMBER
	APPROXIMATE TOP BANK
MI 185	RIVER MILES
	STONE - FILL DIKE
NOTE	SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL

CHANNEL CONFIGURATION

PLANS F-6 RUN 3 AND G RUN 2

SCALES IN FEET

PROTOTYPE 1000 0 1000 2000 3000

MODEL 5 0 5 10

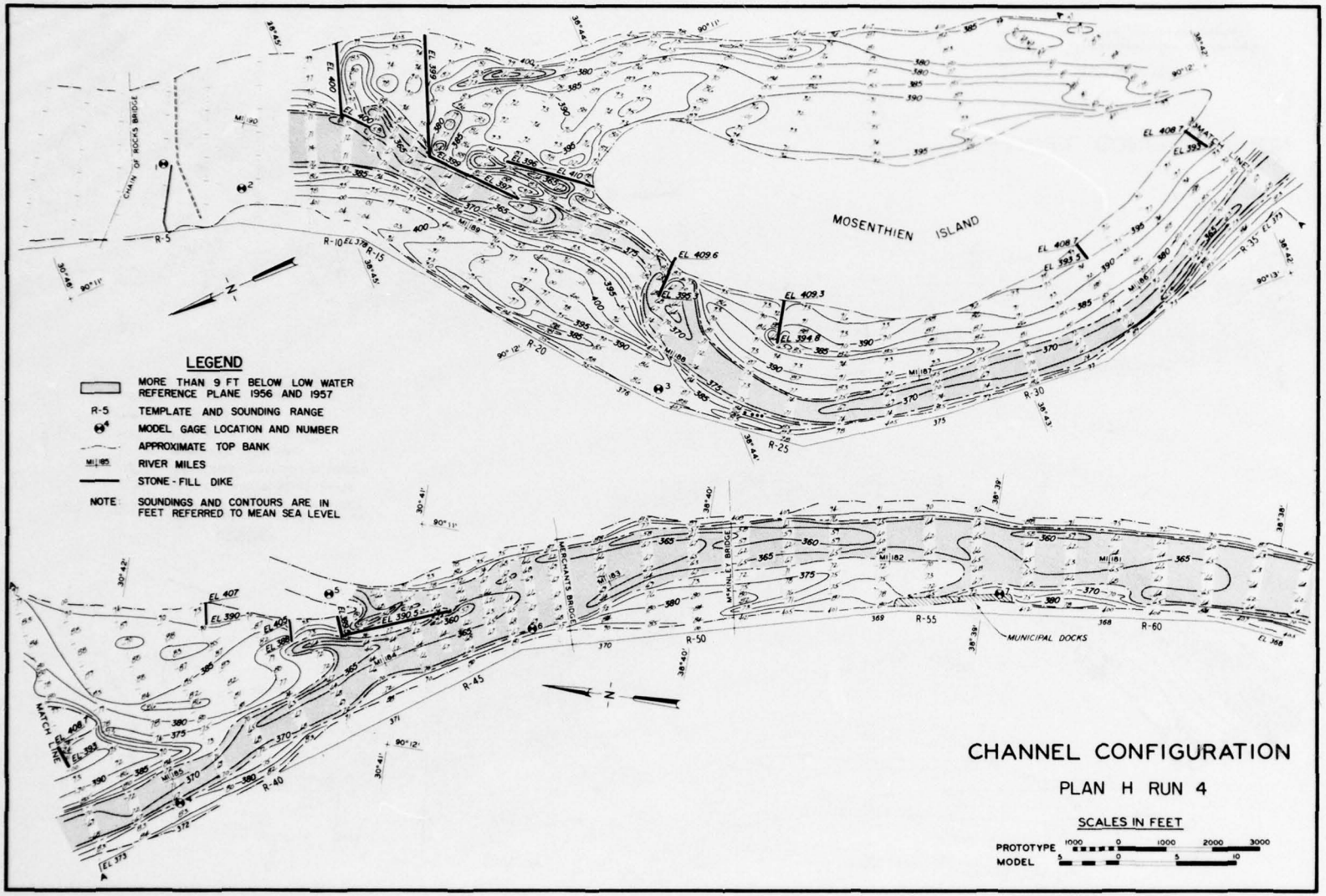
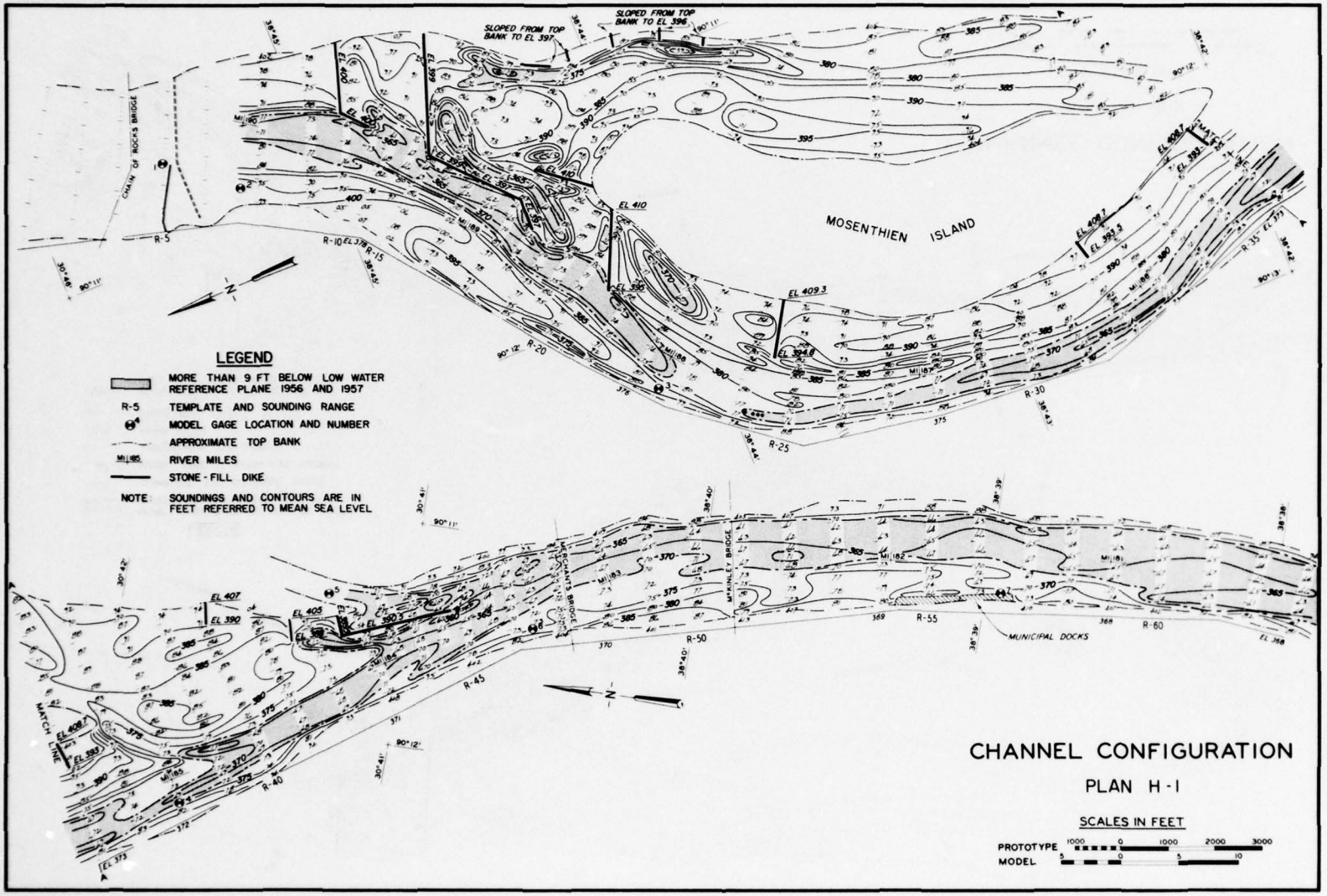

LEGEND
MORE THAN 9 FT BELOW LOW WATER REFERENCE PLANE 1956 AND 1957
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
APPROXIMATE TOP BANK
MI 195 RIVER MILES
STONE-FILL DIKE
NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
MOSENTHIEN ISLAND
CHAIN OF ROCKS BRIDGE
MERCHANTS BRIDGE
McKINLEY BRIDGE
MUNICIPAL DOCKS
MATCH LINE
CHANNEL CONFIGURATION
PLAN H RUN 4
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000 3000
MODEL 5 0 5 10

PLATE 23

PLATE 24


SLOPED FROM TOP BANK TO EL 397
SLOPED FROM TOP BANK TO EL 396
MOSENTHIEN ISLAND
CHAIN OF ROCKS BRIDGE
MCDONNELL BRIDGE
MERCHANTS BRIDGE
MCKINLEY BRIDGE
MUNICIPAL DOCKS
MATCH LINE
LEGEND
MORE THAN 9 FT BELOW LOW WATER REFERENCE PLANE 1956 AND 1957
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
APPROXIMATE TOP BANK
MI 185 RIVER MILES
STONE-FILL DIKE
NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
CHANNEL CONFIGURATION
PLAN H-1
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000 3000
MODEL 5 0 5 10

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Foster, James E
Shoaling conditions in Sawyer Bend and lower entrance to Chain of Rocks Canal, Mississippi River; hydraulic model investigation / by James E. Foster, Charles M. Noble, John J. Franco. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1978.
44 p., 24 leaves of plates : ill. ; 27 cm. (Technical report - U. S. Army Engineer Waterways Experiment Station ; H-78-7)
Prepared for U. S. Army Engineer District, St. Louis, St. Louis, Missouri.

1. Chain of Rocks Canal. 2. Channel improvement. 3. Mississippi River channel improvement. 4. Movable-bed models. 5. Sawyer Bend. 6. Sediment transport. 7. Shoaling. I. Franco, John J., joint author. II. Noble, Charles M., joint author. III. United States. Army. Corps of Engineers. St. Louis District. IV. Series: United States. Waterways Experiment Station, Vicksburg, Miss. Technical report ; H-78-7.
TA7.W34 no.H-78-7